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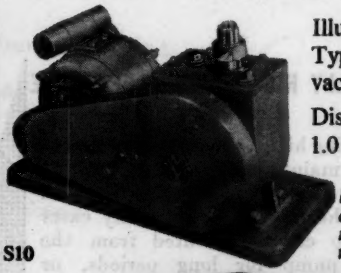

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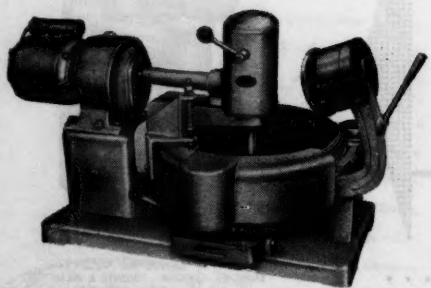

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NATURE

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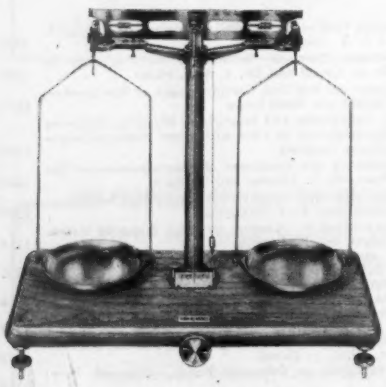

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TECHNOLOGICAL ADVANCE AND EUROPEAN FREE TRADE

LAST September Political and Economic Planning reviewed* the various proposals for comprehensive co-operation between Western European countries, including those of the Spaak report for a free trade area or a common market. At the Dublin meeting of the British Association, Prof. J. E. Meade's presidential address to Section F (Economics) also discussed some of the financial issues involved in the institution of a free trade area in Western Europe. More particularly, Prof. Meade was concerned with the balance-of-payments problem of a European free trade area. He insisted that full employment is more important than free trade for Europe, and indicated three main principles which could form the basis of a workable positive arrangement to enable full employment to be maintained without restrictions in intra-European trade.

At the same meeting, Mr. H. H. Liesner spoke on the European Common Market and British industry, and in the issue of the *Westminster Bank Review* for November 1957 Mr. Richard Bailey, the director of PEP, reviewed objectively the possible shape of a free trade area in Europe. The whole of the issue of the *European Productivity Agency Bulletin* for February 1958 is devoted to European free trade, including articles by Mr. R. Maudling, Dr. Alexander King, Sir Harry Pilkington and others. On these and other occasions in recent months, the proposals for a free trade area have repeatedly been examined, but it is still not entirely clear what is involved in the various proposals or how much the treaties already signed in Rome by six governments will contribute to the unification of Western Europe.

The political difficulties have recently become more apparent. France has always disliked the whole proposal for a free trade area, and even if Mr. Maudling's efforts have allayed some of their suspicions, the counter-proposals of the French may yet wreck the attempt to link Britain and other European countries with the Common Market as the European Defence Community was destroyed four years ago. These proposals, in fact, reject the whole idea of a European free trade area, and would substitute a complicated set of tariff negotiations between groups of industries, in which differences of costs or other factors would be equalized by adjustable duties, while Britain would share with her Continental partners the imperial preference rebates in the overseas Commonwealth, but without corresponding concessions for Commonwealth products in the Common Market. The political implications of free trade are ignored, as is the preference of other European countries such as Austria, Switzerland and the Scandinavian countries for a free trade area.

So much is involved, however, that it is essential that there should be a clear public understanding both of what acceptance of free trade involves and equally of the implications of exclusion of Britain. As Mr. Maudling emphasized in the House of Commons on March 27, the position cannot remain unchanged. During the past two years a large and increasing part of the business world, union leadership, and public and political opinion have recognized the possibility that the European continent may become our main partner, at first in trade but perhaps later in other contexts also.

The problems have been studied in Britain more thoroughly than in any of the six Customs Union countries, but we would not offer free trade to a group of countries with whom we did not wish to develop close political relations. No British Government, for example, could ignore the fact that three-quarters of our external trade is with countries outside Europe; that a fifth of our national product goes into non-European trade; and that freedom to bargain on tariffs with the United States is as vital to us as our trade relations with the Commonwealth.

These dispersed interests cannot be ignored, and the free trade area plan was designed to ensure that, when the six Customs Union countries mutually reduce their tariffs during the next twelve years, the larger region of Western Europe around them reduces its tariffs in parallel. It may well be true, as was argued at the European industrial conference on the subject in London in March, that Europe cannot afford to let Britain stay out, and while there are interests which Britain should not sacrifice, no constructive suggestion which might help to bring Britain and France closer together should be ignored. The new request of France for a share in Britain's liberal trade system with the Commonwealth offers a possible opportunity. A British offer to seek concessions now from the Commonwealth for European trade might unlock the door to the creation of a broad European economic system.

The Common Market was to start operating on January 1, 1959, and the British negotiators still claim that once agreement is reached on the main point, to establish a free trade area, the machinery of the Rome Treaty would rapidly permit detailed application. Agricultural protection remains an issue, and it is now suggested that, in the absence of substantial agreement to set up a free trade area by the end of July, the British Government may abandon the plan.

This issue of agriculture, which was specifically excluded from the proposed area by the White Paper of February 1957, is the one on which Mr. Bailey, of PEP, concentrates attention. The White Paper was published before the Rome Treaty set out the pattern of institutions for the European Economic Community and showed that, although based on the European Coal and Steel Community, they would, in fact, be far less 'supra-national', although representing a considerably greater surrender of control over national policies than the British Government

* *Planning*, Vol. 23, No. 414 (16 September, 1957): Designs for Europe. Pp. 177–196. (London: Political and Economic Planning, 1957.) 2*s*. 6*d*.

has shown itself prepared to contemplate. It is, in fact, already clear that, whatever form the association of Britain with the European Economic Community may take, it will not be the free trade area proposal set out in the White Paper, and Mr. Bailey suggests that the White Paper will be amended on three points.

First, while no one has suggested there should be free trade in agriculture, the difficulty here might be met by a compromise on the basis of the first Report of the Organization for European Economic Co-operation Ministerial Committee, provided that the British farmer is not asked to hand over the working out of the annual price review to the Danes and the French. Secondly, it is now clear that the Commonwealth must be included in the negotiations, and a system of marketing schemes and contracts negotiated for clearly defined categories of products. Thirdly, to overcome the stumbling-block of institutions, Mr. Bailey suggests that the assumption that a free trade area will be a part of the Organization for European Economic Co-operation must be abandoned, and in place of the narrower proposal should be put an imaginative scheme which will bring the Commonwealth countries into association with Europe. A treaty negotiated on this basis could, he believes, unite the trading interests of Britain, Western Europe and the Commonwealth to the advantage of all three.

The special issue of the *European Productivity Agency Bulletin*, however, touches on other difficulties which have been raised, especially by the French negotiators, some of which were indicated by Prof. Meade. Sir Harry Pilkington, for example, stresses the problems of human relations and of diverse commercial and social institutions. The British Government recognized the difficulty of disparities in social security policies, but in the White Paper urged that the harmonization of such policies, which were summarized in a PEP Broadsheet last July*, is only one of a variety of factors—some transitory, some permanent, some natural and some, like taxation and social legislation, man-made—which influence the pattern of international trade. The British Government did not consider it essential that agreement on any one of them should necessarily precede the creation of a free trade area, and Prof. Heilperin has pointed out that the experience of the Benelux countries demonstrates conclusively that price co-ordination is unnecessary and that the freeing of trade does not require a supra-national authority to administer it.

The *Bulletin*, however, is concerned more particularly with industrial aspects. Mr. J. F. Cahan sets forth the imperative character of the European Free Trade Area, Dr. A. King discusses productivity in Europe, M. A. Frisch indicates the point of view of European industry, while the implications of free trade for a functional Europe are set forth with some imagination by B. Gandrille. Unless needs such as those that resulted in the Treaty of Rome and the benefits attendant on an extension of the free trade area are widely understood, it is unlikely that the effort will be made or the changes accepted, even if—as may well be—they are a necessary condition for the survival of Western European civilization as we have known it.

Mr. Liesner, who was concerned with the prospects of British industry in the European Common Market, produces evidence that there is a substantial difference between British and Continental industries as regards efficiency. Accordingly, he believes the United Kingdom will gain from participation in the Common Market by specializing on lines of production in which she is relatively efficient and surrendering other lines in which she is relatively inefficient. The resultant benefit depends on various factors, including the availability of further economies of scale in Britain and on the Continent, but is largely determined by the difference of costs in Britain compared with the Continent. Therefore, Mr. Liesner concludes, free trade in Europe should be able to contribute substantially to a higher standard of living in Britain, and the difficulties of adjustment which will attend a marked difference in comparative costs when trade barriers are abolished are a small price to pay for the lasting benefits that would accrue to Britain from the establishment of a European free trade area.

While there were exceptions, and the need for safeguards was stressed, the replies received last November by the Board of Trade indicated that a majority of business and industrial opinion is prepared to accept the idea of mutual free trade with Western Europe. The advantage which extended markets offer to increased productivity, especially in the technically advanced industries, is far more generally recognized. The proposals are seen to be inherent in an era of rapid technical change as a condition for the realization of new possibilities of production and improvements in standards of living. Obviously there are social effects for which provision has to be made, as in automation, but this is part of the technique of adaptation that is already inescapable. As Dr. King indicates in his article, all proposals merely emphasize the need for much deeper knowledge of human attitudes to change and for a European programme of research on the human sciences as applied to industry.

It is important to realize, moreover, that we have here large opportunities of economizing in trained man-power through a co-operative attack on such problems, the urgency of which is quite independent of the advent of a European Free Trade Area or the Common Market. The social changes likely to result will probably be small compared with those which technical change itself is imposing on the industrial and social structure, even though it is expected that 15 per cent of British firms would have to modernize their processes, concentrate their products or change their lines if they are to survive under free trade. None the less, the psychological effects can be important and need study as well as foresight, just as in all processes of technological innovation, and it is to this aspect that the Government itself and the trades unions should be giving more attention.

* *Planning*, Vol. 23, No. 412 (15 July, 1957): Free Trade and Social Security. Pp. 141–156. (London: Political and Economic Planning, 1957.) 2*s*. 6*d*.

Although attention has latterly been shifted from the technical to the political aspects, it should be remembered that the technical implications are of compelling importance, and that the character and nature of technological change demand political and economic institutions appropriate to the new age. As M. Jean Gérard observed in January 1956 in his Jubilee Memorial Lecture on European Technical Co-operation, before the Society of Chemical Industry in Glasgow, technical progress has become a key factor in productivity. The nations of Europe cannot afford to use up their strength in disastrous competition. They must co-ordinate their activities, technically as well as economically, and make the most of their resources by a more rational deployment.

M. Gérard placed steady progress in the chemical industry as a first essential, and suggested that in this field effective liaison, adequate education and efficient documentation would permit some objectives to be attained fairly quickly. He advocated co-operation in research in certain limited fields, quite apart from those, such as nuclear research, in which the immense cost of equipment and facilities points to a joint international undertaking as the only economical proposition.

In the field of patents, M. Gérard instanced the proposal, made at Strasbourg in 1949, for a European Patent Office, not to grant patents—although it would issue a European certificate of invention—but to carry out a search for prior applications or patents, to which all member countries would submit inventions patented by their own nationals. Standardization and development were other fields in which M. Gérard visualized possibilities of fairly rapid advance. This lecture by the vice-president of the Société de Chimie Industrielle is welcome evidence that there are Frenchmen bringing wide vision to bear on problems of international co-operation.

Prof. C. E. Carrington, in a recent book on "European Integration", has asserted that "National sovereignty is no longer relevant in the mid-twentieth century. . . . The great progressive nations are concerned with quite different plans which accord better with the spirit of the age". None the less, the slow progress made by the concept of a free trade area indicates that nationalism is still a strong force which hinders the creation of wider institutions and units better adapted to serve the needs of an era of rapid technological change. If opposition is to be overcome and support won for the new forms of co-operation needed to-day, there is still a long task of education and explanation to be undertaken, and in this the scientist and technologist have a large part to play.

The papers read before the British Association in in Dublin indicate one type of opportunity, and M. Gérard's lecture another. There are the studies of technical change and industrial relations for which PEP is responsible and those fostered by the Department of Scientific and Industrial Research and the European Productivity Agency. The scientist and technologist have a duty to use such opportunities as may be theirs to explain why new institutions may be needed and what, from the professional point of view, their nature should be. But it is as citizens that they should urge on the attention of their fellow countrymen the need for action, and should seek to ensure that such considerations are rightly understood and their bearing on standards of living and industrial productivity is realized by those in whose hands the political and economic decisions lie.

Finally, it must be realized, as Mr. Maudling stressed in the House of Commons, that the alternative to a free trade area is not the perpetuation of the *status quo*. A changing Europe will be served by new institutions, and the fundamental issue is the shape which they should take in the economic sphere if they are both to safeguard what is best in the existing structure and enable us to enjoy the full benefits which technological advance has made possible to-day.

EVOLUTION OF THE PRIMATES

Fossil Men

A Textbook of Human Palæontology. By Prof. Marcellin Boule and Prof. Henri V. Vallois. (Translated from the revised and enlarged Fifth French edition of "Les Hommes Fossiles", by Michael Bullock.) Pp. xxv+535 (298 figures). (London: Thames and Hudson, Ltd., 1957.) 84*s*. net.

Traité de Paléontologie

Tome 7: Vers la Forme Humaine. Le Problème Biologique de l'Homme. Les Époques de l'Intelligence. Primates—Paléontologie Humaine. Par Jean Piveteau. Pp. vi+676+8 planches. (Paris: Masson et Cie., 1957.) Broché, 12,000 francs; Cartonné toile, 12,800 francs.

THE gradual augmentation of the fossil record of the Primates over the past twenty-five years or so, and more particularly the remarkable accession of fossil material from various parts of the African continent, have provided an incentive for the collation of all the new evidence, as well as a general re-assessment of the evidence provided by previous discoveries. Critical reviews of this palæontological material have appeared from time to time in scientific journals, and more comprehensive studies have quite recently appeared in the first parts of the ambitious Swiss publication *Primatologia* (namely, Remane's "Paläontologie und Evolution der Primaten", and Heberer's "Die Fossilgeschichte der Hominoidea"), as well as the seventeenth volume of Grassé's "Traité de Zoologie". The whole subject of the evolution of the Primates, with special reference to the origin of man and his immediate forerunners, has now received yet further attention in two new volumes, namely, Vol. 7 of "Traité de Paléontologie", by Dr. J. Piveteau, and the fifth edition of the well-known text-book "Les Hommes Fossiles", by Marcellin Boule and Prof. Vallois (translated into English).

These books are in some sense complementary to each other, and also offer interesting contrasts. The former is by a palæontologist and traces the fossil record of the earlier Primates as well as that of the higher Primates in some detail; the latter is by an anthropologist and focuses attention mainly on the palæolithic history of the Hominidæ. Of the authors of the two volumes, Dr. Piveteau has evidently approached his task at an advantage, partly because

his book is an original work which he has planned *ab initio* as the primary author, and partly because with his long experience he is able to present the subject with the mature perspective of a palæontologist. On the other hand, Prof. Vallois (Marcellin Boule, whose name still appears on the title page as part-author, died sixteen years ago) has been seriously handicapped because he has evidently striven to retain the general character, and even many of the detailed descriptions, of his distinguished predecessor's work, in order (it would seem) to perpetuate it as a sort of 'classic'. Classic it is, no doubt, in the sense that for many years "Les Hommes Fossiles" was the only general text-book of its kind.

But the time has surely come when some of the original (and now obsolete) material needs to be eliminated, and more attention given to recent developments in the materials and techniques of palæo-anthropology. Thus, the statement is still repeated (based on a remark by Testut almost seventy years ago) that Magdalenian man, as represented by the Chancelade skeleton, had a divergent hallux approaching in character that of the apes. The Middle Pleistocene hominid discovered in China is still referred to as *Sinanthropus*, even though it has been firmly established that it is not to be distinguished generically from *Pithecanthropus*. The Talgai skull is still credited with interlocking canine teeth, though it was clearly demonstrated thirty years ago by A. N. Burkitt that the so-called 'attrition' facet for the first premolar is really an interstitial facet. The remains of the infamous 'Piltdown Man' still receive almost as full a descriptive account as in previous editions, but with a final *dénouement* in a brief reference to the exposure of this fraud. It is a pity, also, that more attention is not focused on recently developed methods of geochronology, for it has become apparent that the time factor is of quite paramount importance for the interpretation of the phylogenetic significance of fossil types.

Other criticisms which occur to the reader concern the vague and sometimes contradictory terminology. The terms 'humans', 'hominids', 'hominians', 'Presapiens', etc., are used with no definition of their intended meaning, and the phrase "humans properly so called" only serves still further to enhance the confusion introduced by labels of this sort. *Pithecanthropus* is stated on one page to be a hominid, and is yet included in an undefined category of extinct types called 'prehominids'. We could wish that all anthropologists be asked firmly to eschew such indeterminate and puzzling labels, and particularly to avoid the common usage of a generic term as though it referred only to a few individuals. A genus is a taxonomic category consisting of groups of populations, often widely spread in time and space, and commonly represented by numbers of species and geographical varieties. Thus, when the proposition is advanced that the genus *Australopithecus* may have been ancestral to the genus *Homo*, this must not, of course, be taken to imply that the individual specimens of one local variety of *Australopithecus* which by a lucky chance have been found in South Africa *themselves* represent direct ancestors. When anthropologists come properly and consistently to recognize that the units of evolution are populations and not individuals, much of the argument which is so commonly aroused by discoveries of isolated remains of fossil hominids will certainly be avoided.

Dr. Pivetau's book is comprehensive and up to date. Since Abel's "Die Stellung des Menschen im Rahmen der Wirbeltiere" of 1931, it is without doubt the most complete and authoritative survey of Primate palæontology which has been attempted. As might be expected, the palæontological record of the earlier Primates, which were not only small creatures but also presumably of forest habitat, and therefore only by rare chance likely to be perpetuated as fossils, is far from decisive for determining evolutionary lines. They demonstrate general trends of evolution rather than linear sequences. The larger Primates of later times are better represented in the sense that they appear to approximate more closely to a linear sequence, and, as Dr. Piveteau points out (and other recent expositions also emphasize), their fossil record now provides a fairly continuous and close gradation in the evolutionary sequence of the Hominidæ ranging from *Australopithecus* through *Pithecanthropus* to *Homo*. This is not to say, of course, that the fossil history of the Hominidæ is anything like complete as yet, for, in spite of the problematical and disputed Pliocene genus, *Oreopithecus*, there still remains a serious hiatus between the Early Pleistocene hominid, *Australopithecus*, and the presumed common ancestral stock which also gave rise to the modern large apes. But that the filling in of blank spaces in the palæontological record of the Primates has been proceeding with a somewhat unexpected rapidity is made clear by the two volumes under review.

W. E. Le Gros Clark

RHEOLOGY ON THE LAND

Agricultural Rheology

By Dr. G. W. Scott Blair and Prof. Markus Reiner. Pp. xii+222. (London: Routledge and Kegan Paul, Ltd., 1957.) 28*s*. net.

In a preface the authors announce their aim to be the presentation of rheology to suit the needs of the student reading a course of agriculture or agricultural engineering at a British university or college. They confess to experiencing difficulty in blending the necessary theoretical background, Part 1 of the book, with an account of the practical aspects of the subject, Part 2; and indeed, they have not been wholly successful, for the book is uneven. Some chapters comprise the strictly logical mathematical analysis of a topic in a manner acceptable to a first-year physics student, while others revert to plainly descriptive matter. Although it is said that Part 2 cannot be read with profit without the preliminary mastery of Part 1, much of that preliminary treatment is not, in fact, again referred to. Nevertheless, the production of this book must be accounted a notable and courageous act of faith on the part of the publishers and authors, for the agricultural student is not often, either by nature or previous training, very receptive of closely reasoned and mathematically expressed arguments about physical topics.

Part 1 is devoted to chapters on the nature of stress and strain in solids and fluids; and on elasticity, the viscous flow of Newtonian fluids, and engineering hydraulics. These treatments are all thoroughly acceptable, and indeed contain some excellently lucid statements of definition, but they traverse well-trodden paths. There follows a more enterprising group of chapters on the phenomena of plasticity, including time effects and the nature of

the strength of plastic materials. This topic does not lend itself to the same kind of simple exact treatment as does the earlier matter. That intriguing tool, the differential coefficient of fractional order, is introduced only for the reader to be told that elaboration of the method is beyond the prescribed scope. The essential results are quoted, as they could have been had the mathematical concept never been mentioned. These chapters are, in fact, devoted to quantitative definitions of plastic phenomena by reference to experiment and to mechanical analogues.

Part 2 comprises chapters on the rheology of soil; of certain animal secretions resulting in the development of diagnostic aids to stockbreeders; and of certain farm products including milk and milk products, flour doughs, honey and wool. This is all done in a descriptive manner which will be very acceptable to the agricultural student, who is required to master only the definitions of properties in Part 1. Room has been found in this section for a chapter on the design of load-bearing members in buildings, a topic which is not rendered specifically agricultural by reference to farm buildings. Yet the vital and fast-developing subject of soil water movement, with applications to irrigation, drainage and soil profile development, is dismissed with a treatment of Darcy's law occupying half a page in Part 1.

E. C. CHILDS

POISONED AIR

Air Pollution

Based on papers given at a Conference held at the University of Sheffield, September, 1956. Edited by M. W. Thring. Pp. x+248. (London: Butterworths Scientific Publications, 1957.) 42*s*.

THERE has, over the years, been plenty of propaganda about the evils of air pollution; but it has been rather the disasters of Donora, Liège, Los Angeles and London that have produced political action. The continuing pollution over most of Britain is so appalling that the editor of "Air Pollution", a symposium based on lectures given in Sheffield in 1956, might well have ensured that these disasters were not mentioned more than once. The smoke with which we in Britain afflict ourselves is a national addiction which only knowledge of the kind represented in these papers, rather than propaganda, will help us to overcome.

The excellent article by G. Nonhebel on various solid and gaseous pollutants makes one realize that pollution is not simply a matter of dark smoke (against which it is easy to legislate). The chapters on health (J. Pemberton), damage to structures (R. J. Schaffer) and vehicle exhaust (A. Fitton) are well balanced and critical without being difficult. There are useful chapters on boilers, gas-cleaning plants, domestic grates and pollution problems in the steel, cement and similar industries, mostly by authors from Sheffield. Since one is less likely to read straight through than to search for information about special topics, it is a pity that there is no index to make all this valuable material more accessible. It would also have revealed some duplication.

For an authoritative book on air pollution there is a serious lack of critical and expert treatment of the behaviour of the air itself. It is attempted unsatisfactorily by Dr. Alice Garrett. She describes mainly the effects of topography on the distribution of pollution, but many of her maps do not necessarily lead to the conclusions she suggests because of effects she does not consider. Some deductions could be vitiated by drawing contours differently where there are no measurements, and statements about washing-out of pollution by rain are glib, because rainfall is correlated negatively with the occurrence of calm stable air in which pollution accumulates. Not that the conclusions drawn are wrong—but they would be better argued from general meteorological principles than from particular instances in which all the effects are not considered. The emphatic statements about hygroscopic particles are misleading quarter-truths: it is implied that ordinary air can become noticeably supersaturated. The effects of having nuclei in large numbers and the radiative properties of airborne solids, which are more important than their hygroscopic properties, are ignored. It is implied, quite incorrectly, in Fig. 10, that smoke simply goes upwards in unstable air but downwards in stable air. The description of atmospheric turbulence is naïve and is couched in a fifth-form terminology quite inappropriate to a book of this calibre.

The description of the standard measuring instruments by E. T. Wilkins is correct, but one would think from it that the staff of the Fuel Research Station was quite satisfied with them. The inadequacies of the deposit gauge are not mentioned, and the difficulty of obtaining a proper record of short periods of intense local pollution is not discussed.

Finally, C. H. Bosanquet's eloquent exposition of how he derived his formulæ for the dispersion of hot gases in a cross-wind (marred by two misprints on p. 118—'position' for 'portion' and 'considered' for 'constant') should make his valuable but difficult work more accessible. Here also a statement of the circumstances in which the formula is inapplicable would have been valuable. As it stands this chapter teaches one nothing about the atmosphere.

Prof. M. W. Thring (and Sheffield) has made available a good elementary book in which the approach is informative without being propagandist. Besides its use to engineers and administrators, it will help the specialist scientist to obtain a broader appreciation of the subject.

R. S. SCORER

ATOMIC ENERGY FOR UNDERDEVELOPED COUNTRIES

Atomic Energy Applications with reference to Underdeveloped Countries

A Preliminary Survey. By B. C. Netschert and S. H. Schurr. Pp. xiv+129. (Baltimore, Md.: The Johns Hopkins Press; London: Oxford University Press, 1957. Published for Resources for the Future, Inc.) 16*s*. net.

THIS short survey was prepared by Resources for the Future, Inc., at the request of the Ford Foundation.

The survey opens with a brief and substantially accurate account of the principal applications of atomic energy and their present status.

The next section surveys the conditions which are necessary in underdeveloped countries if nuclear energy is to be worth using. Nuclear power from small output units has a much higher capital cost than conventional power units such as the Diesel type. This high capital investment will be a serious

handicap to their use. It is mitigated to some extent by the fact that a coal-based economy requires a great investment in railroads and coal mines, so the overall picture must be considered. This point was also emphasized by Prof. H. J. Bhabha in his address to the British Association in Dublin.

The production of radioactive isotopes is not likely to be economically worth while in the smaller underdeveloped countries owing to the high cost of processing laboratories and the relatively low cost and easy availability of radioisotopes from countries such as Britain.

The principal use of radioisotopes is thought to be in agriculture and medicine. The radiation preservation of food is briefly discussed, but it is clear that much more extensive surveys of the advantages and storage arrangements in individual countries are required.

The application to medicine in underdeveloped countries similarly awaits identification and detailed study of the medical and public health problems of individual countries. A section on reactors gives details of the capital and operating costs of particular reactors and makes the point that they are only of use if there are institutions and research workers capable of carrying out research or teaching. There are far too many cases to-day of research reactors being installed as a result of high-pressure salesmanship where these conditions are entirely lacking.

In general, then, this survey does no more than pose the problems. They can only be answered by an 'on the job' study. The Baghdad Pact Nuclear Training Centre seems to be the first centre where a serious attempt is being made to investigate these questions.

J. D. Cockcroft

SEMICONDUCTORS AND TRANSISTORS

Semiconductor Abstracts, Vol. 3—1955 Issue

Compiled by Battelle Memorial Institute. Edited by E. Paskell. (Abstracts of Literature on Semiconducting and Luminescent Materials and their Applications.) Pp. viii+322. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 80*s*. net.

Progress in Semiconductors, Vol. 2

Edited by Dr. Alan F. Gibson, Prof. R. E. Burgess and Prof. P. Aigrain. Pp. vii+280. (London: Heywood and Company, Ltd., 1957.) 63*s*. net.

Fundamental Principles of Transistors

By Dr. J. Evans. Pp. xii+255. (London: Heywood and Company, Ltd., 1957.) 45*s*. net.

Transistor Electronics

By David Dewitt and Arthur L. Rossoff. Pp. xii+381. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 60*s*.

THE subject of semiconductors was, not so long ago, a small, rather untidy, corner of physics. It has grown rapidly in the past ten years and spread into other branches of science under the impetus of several important discoveries, of adequate theories in support and of much improved material technology. Because progress in one of the branches is often dependent on progress in another, many physicists, chemists, metallurgists and engineers engaged in the subject regularly follow one another's journals, where necessary by way of the monthly parts of the well-established, but broadly based, abstracting journals. The annual "Semiconductor Abstracts" of the Electrochemical Society cannot be published quickly enough to form an alternative early collection of references, but they can serve other purposes; they are a compact source, useful alike to newcomers and to anyone making a detailed study of a particular line of research. They are well laid out and, in part, original; they include papers read at American meetings, not necessarily published, and emphasize numerical results. A study of Volume 3 shows that the period covered was largely one of consolidation, although there were some important papers, particularly from the Massachusetts Institute of Technology, the Bell Telephone Laboratories and the Philips Laboratories.

"Progress in Semiconductors" is another recent annual publication, designed to keep readers well informed by authoritative reviews. Its first volume was welcomed, even though some of the reviews were insufficiently searching or, apparently, hurriedly written. The second volume, for which important subjects have again been chosen, suffers from no such blemishes. Without exception all eight contributions are informative, critical and adequately illustrated. The first two deal with materials; that on semiconductor alloys deals largely with the silicon–germanium system and is directed mainly at experts, but that on the compounds of Group III and Group V elements should appeal more widely. The third summarizes the many investigations made of the effects of irradiation of semiconductors and the fourth analyses the factors controlling that important property, the life-time of minority carriers. There follow a very good description, with some excellent plates, of the production of monocrystalline germanium of high physical perfection and an account of the behaviour of small amounts of impurities, of many elements, in germanium. The last two papers deal with effects at high electric fields, the first with the motion of carriers and the departure from ohmic conductance and the second with theories of luminescence, which postulate a supply of electrons, their acceleration and their collision with luminescence centres. The editors have set themselves a hard task if they are to maintain the standard set by this volume; there is no shortage of subjects worthy of attention, and we can surely look forward to future volumes.

Dr. Evans's book, though likely to be most used by physicists and engineers embarking on the theory, design or manufacture of transistors, can be widely read with interest. It is well balanced, except for a small over-emphasis on point-contact transistors, and presents its facts concisely. It has little space for detail, but should encourage readers to follow up the references given.

American authors have written some of the very best books about the thermionic valve, and its uses, and recent evidence suggests they are beginning to do the same with the transistor. "Transistor Electronics" is a good pointer. It may have its faults—perhaps it makes insufficient distinction between the more important and the less important and could be more quantitative in places—but the descriptions it gives of the internal behaviour of transistors in physical terms, of the external behaviour in electrical terms, and of the elementary circuits in common use, fulfil the authors' purpose that the book should prepare engineers to use the transistor with understanding and confidence.

J. R. Tillman

CELLULAR CLOCKS*

By Prof. ERWIN BÜNNING
Botanisches Institut, Tübingen

IT has become evident from recent research that exact timing reactions in organisms are of great importance. Human beings have a sense of time which enables them to estimate the time of day after several hours or even after a couple of days without external hints, with errors sometimes less than 1 per cent. Even lower animals have such a sense of time: bees may be trained to certain feeding times, and in addition, bees, other arthropods and many birds need an internal 'clock' in connexion with their ability to navigate by the Sun. The clock enables them to determine the correct angle between the direction of the Sun and their own flight in spite of the apparent motion of the Sun. Other examples of physiological measurements of the course of time are provided by photoperiodic reactions in certain plants and animals. Such organisms inherit some time-standard with which, day by day, they compare the actual length of day. If the actual length of day is longer or shorter by an appropriate amount than the standard time (the 'critical length of day'), some reaction, such as flower-formation in plants, or the beginning of the rest-period in buds or in insects, is initiated. In these and other cases, the plants and animals concerned can measure periods of several hours with errors of only a few minutes.

In several cases at least we know that the organisms are measuring time not on the principle of the hour glass, but by means of cyclic diurnal processes: this applies to the sense of time in arthropods and for the photoperiodic reactions. It has been stated by several workers that the sensitivity of plants to light changes in a diurnal pattern, quantitatively and qualitatively, even after several days under constant conditions. This endogenous diurnal periodicity is most easily studied, not by its influence on the sensitivity to light and darkness, but by measuring other physiological reactions which are also coupled with the clock. Suitable processes are, for example, the emergence of insects from their pupæ, the running activity of animals, spore discharge in algae and fungi, rate of growth, and the movements of leaves. Processes like these may, with many species, continue to show diurnal fluctuations while external conditions are constant.

The diurnal cycles of light and darkness as well as those of high and low temperature are factors regulating the endogenous periodicity. A change in the pattern of these external factors results in a shift in phase of the endogenous rhythm. The rules governing these interactions have been studied by several research workers. They are similar in plants and animals. In order to reach a complete inversion of the rhythm, 2–10 days of an inverted light–dark periodicity are required. With plants or animals raised under constant conditions, a single stimulus, such as transition from continuous darkness to continuous light, or a short period of light interrupting continuous darkness, is frequently necessary to evoke the periodicity. This phenomenon is apparently to be explained by a synchronizing effect of the stimuli on the several cellular 'clocks' inside a tissue or inside the whole individual. In addition, the external factors normally force the endogenous rhythm into periods of exactly 24 hours.

After eliminating the regulation by external factors, the length of the endogenous cycles may vary between 22 and 28 hr., and even in standard conditions differences between the individual plants or animals can be recognized. The specific length of the period in a single individual, however, differs from day to day sometimes by only a few minutes. This specific length is inherited and proves to be constant through many generations.

Details of several experiments have been published showing the regulation of the rhythms by glands, and there is the role of hormones in vertebrates as well as in arthropods. Diurnal variations in the sensitivity of the nervous system seem to be of importance in inducing variations in the quantity and quality of physiological processes. But there are also examples of endogenous diurnal rhythms in isolated tissues of vertebrates. Plants never use a central regulation of the periodicity; they have a 'clock' in every single cell. This becomes clear from experiments with isolated tissues, but especially from experiments with unicellular algae (that is, from diurnal fluctuations in phototactic sensitivity of *Euglena*, and diurnal changes in luminescence of *Gonyaulax*).

Experiments on the influence of temperature on the endogenous rhythms are of interest in the study of the 'clock' mechanism. In the range 15–30° C., or even 10–30° C., the speed of the 'clock' is not at all or only very little influenced by temperature in the higher plants, unicellular algae, arthropods or vertebrates. The absence of a marked influence of temperature is especially surprising, since immediately after a reduction in temperature there is a distinct increase of the first period by some 5–10 hr. It looks as if plants and animals become accustomed to the new temperature within a single day. There is still another striking fact. While the 'clock' is independent of temperature between about 10° and 30° C., a drop in temperature to 0–10° C. seems to stop the 'clock'. That means that after chilling the plants or animals for several hours, the next maximum of the rhythm to be observed after re-establishing the higher temperature will be delayed by several hours. A further analysis, however, shows that this is due to something other than stopping the 'clock'. After a period of chilling to values in the vicinity of 5° C., for more than about 10 hr., the same period at normal temperature must always elapse before a new maximum of the cycle occurs. This implies that the abnormally low temperature does not fix the oscillator in the phase which was prevailing at the onset of chilling: instead, the effect of low temperature is to make the oscillator relax into its zero position. This suggests that the cycles may be regarded as the periods of a relaxation oscillator (Fig. 1). This is confirmed by offering the low temperature in different phases of the cycle. There is, in both plants and animals, one phase of several hours which cannot be delayed very much

* Based on a course of three lectures on "Endogenous Diurnal Periodicity in Plants and Animals", delivered at King's College, London, on March 4, 5 and 7.

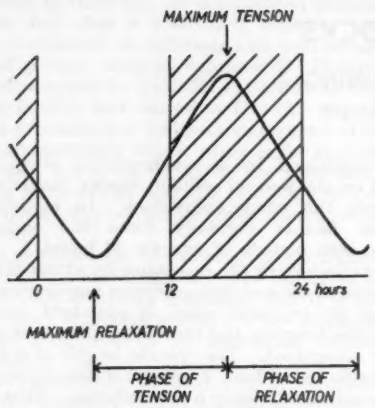

Fig. 1. The endodiurnal oscillator of plants and animals regulated by light–dark cycles. Quantitative details based on results with beans. Dark period hatched

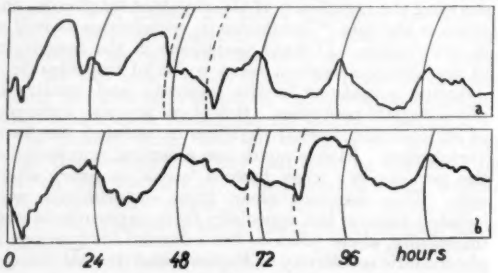

Fig. 2. Kymograph records of leaf movements in the bean (*Phaseolus multiflorus*) at 20° C. In the interval between the broken lines, the temperature was 5° C. Note different effect, depending on the phase in which the plant is chilled: little or no delay in *a* (low temperature during phase of relaxation); strong delay in *b* (low temperature during phase of tension)

by chilling; but low-temperature treatment of the other phase makes the oscillator drop to its zero value, thus causing a delay (Fig. 2). The former is the relaxation-, the latter the tension-phase. Replacing oxygen by nitrogen causes a similar strong delay during the phase of tension.

The speed of tension and relaxation always seems to be independent of temperature, but if we replace, say, 25° C. by 15° C., the oscillator drops to a lower energy-level than before, since the supply of energy is delayed. This delay only allows the oscillator, when again entering the phase of tension, to reach a lower level of energy than during tension at higher temperatures. Thus at lower temperatures the system oscillates between lower levels of energy than at higher temperatures, and the first cycle after a fall in temperature is necessarily longer (Fig. 3*a*). After bringing the plant to a still lower temperature (for example, 8° C.), the energy supply will be so much delayed that the oscillator drops to zero energy-level during relaxation, and very little tension is possible. Consequently the periods are much reduced (say, about 10 hr. instead of 24 hr., Fig. 3*b*). Still lower temperatures allow no tension at all; the oscillator relaxes to zero energy-level and will keep this as long as the very low temperature prevails.

Experimental results from plants (diurnal leaf movements of beans) and animals (running activity of the cockroach, *Periplaneta americana*) are in harmony with those theoretical conclusions (Fig. 4).

Thus it appears that the endogenous periodicity is a relaxation oscillation. The tension requires a supply of energy by respiration, but this does not necessarily mean that the oscillator itself is a chemical system.

Organisms use their 'clocks' for very different purposes. Plants use them in order to establish diurnal fluctuations in the photoperiodic light sensitivity. They do this, at any rate in the better-known cases, through an effect of the endogenous periodicity on the so-called photomorphogenetic pigment system. A phase of high sensitivity to red light alternates with a phase of high sensitivity to the far-red. Much more complicated is the utilization of the 'clock' in the case of animals, among which it may serve quite different purposes. Even lower animals like arthropods, which use the 'clock' in connexion with their Sun navigation, may also employ it in order to visit feeding places at suitable times of the day. The 'clock' even allows them to have a memory for different suitable daily feeding times, and to know at which of several different places they are to search during these different times of the day. Still more complex are the processes which can be coupled with the internal 'clock' in higher animals and human beings.

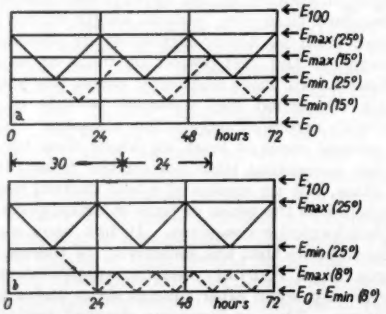

Fig. 3. Oscillation at different temperatures. Horizontal lines represent levels of energy: E_{100}, maximum possible tension; E_0, maximum possible relaxation; $E_{max.}$, level of energy at which tension ends and relaxation begins; $E_{min.}$, level of energy at which relaxation ends and new tension begins. Note in *a* that if temperature falls at the beginning of the experiment and remains low (15° C.) throughout the three days, the first period increases, the following ones are normal in length, but the oscillating occurs now between lower levels of energy (broken line shows oscillations at 15° C.); whereas in *b*, if temperature falls at the beginning of the experiment to still lower values, the first period is again increased, but the following ones are very short, due to restricted tension processes (broken line represents oscillations at 8° C.)

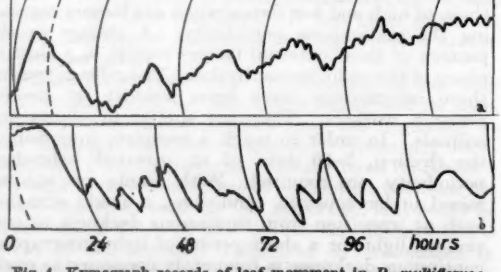

Fig. 4. Kymograph records of leaf movement in *P. multiflorus*: (*a*) at the time indicated by broken line the temperature fell to 15° C. (where it was maintained thereafter). Note increase in first period to about 36 hr., and return to 24-hr. periods later (cf. Fig. 3*a*); (*b*) at the time indicated by broken line the temperature fell to 10° C. Note occurrence of very short periods (cf. Fig. 3*b*)

We are not yet sure whether the 'clock' in plants, and that in the lower and higher animals, depend on the same type of clock-work, although this assumption would be the simplest working hypothesis. The similarities in the qualities of the 'clocks' of the different organisms are striking.

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CRITICAL MASS MEASUREMENTS FOR THE MERLIN RESEARCH REACTOR

By D. R. CHICK, K. FIRTH, M. KERRIDGE and A. J. SALMON
Associated Electrical Industries, Ltd., Aldermaston

THE Merlin research reactor[1], now nearing completion at the Associated Electrical Research Laboratory, Aldermaston, is a light water-moderated reactor using highly enriched uranium fuel. Each fuel element in the core comprises fourteen active and two blank plates, $2\frac{7}{8}$ in. wide by 25 in. long, brazed together with spacing pieces at the long edges to form a box with a gap of 0·130 in. between adjacent plates. Each plate contains a nominal 10 gm. of uranium-235 in the form of an alloy of 20 per cent by weight uranium (93 per cent uranium-235) and aluminium which is completely sealed in aluminium cladding. The thickness of the plates is 0·058 in., the central 0·018 in. being the uranium–aluminium alloy, which is 23·6 in. long. A top handling section is fixed to the box, and there is a hollow spigot at the lower end by means of which the fuel element stands vertically in a hole in a lattice plate. Some partial fuel elements with 1, 2, 4 and 6 plates each are provided so that the amount of uranium-235 in the core can be adjusted in steps of 10 gm.

The lattice plate supporting the core has a square array of holes on a 3-in. pitch to accommodate a core of up to 49 fuel elements. There are gaps $\frac{3}{8}$ in. wide between the rows of elements to accommodate the control and safety elements (Fig. 1).

For a volume of the core, 3 in. × 3 in. × 23·6 in. occupied by a complete fuel element, the volume fractions of the various constituents are: uranium-235, $2{\cdot}095 \times 10^{-3}$; uranium-238, $1{\cdot}55 \times 10^{-4}$; aluminium, 0·33400; water, 0·66375; that is to say, in ratios of 1 : 0·0740 : 159·4 : 316·8. The critical mass for a square-section core of this composition, neglecting control-element gaps, has been calculated using two-group neutron-diffusion theory and assuming the core to be homogeneous. Following a procedure which has been adopted for uranium–graphite reactors[2], one parameter (the neutron regeneration factor, η) has been regarded as an empirical constant; a value was chosen, $\eta = 1{\cdot}965$, which gave agreement between a critical mass calculated for the similar Harwell reactor LIDO and the reported experimental result[3]. The calculated critical mass for Merlin was then 2·61 kgm. uranium-235. A calculation by three-group theory, using a value for η of 2·07 and other constants as given by Deutsch[4], gives a result of 2·68 kgm.

The effect of the control-element gaps is somewhat uncertain. It is not reasonable to treat the additional water as though it were uniformly distributed in the core, thereby altering the volume fractions; on the other hand, it is over-pessimistic to regard the water in the gaps as a parasitic absorber only. However, the last assumption was used to estimate the likely upper limit of critical mass. The value calculated, using two-group theory, was 3·03 kgm. uranium-235.

The reactor has three cruciform-section control- and safety-elements, each designed to control 5·5 per cent reactivity, and a flat-plate element to control 0·5 per cent reactivity. These units move vertically in the gaps in the core. During operation, reactivity balance is maintained by adjustment of the fine element and one coarse element. The other two elements are for safety and shut-down purposes. Normally, they are held withdrawn from the core ready for immediate emergency action.

In view of uncertainties in design calculations for the reactor core a sub-critical facility has been built primarily for the experimental determination of critical masses before the reactor itself is made critical. In its essentials, the apparatus consists of a tank with a lattice plate in which fuel elements can be placed as in the reactor, to which water can be

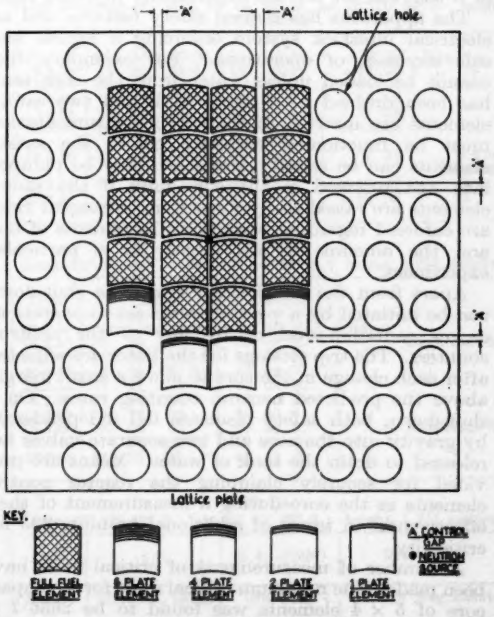

Fig. 1. Typical core assembly

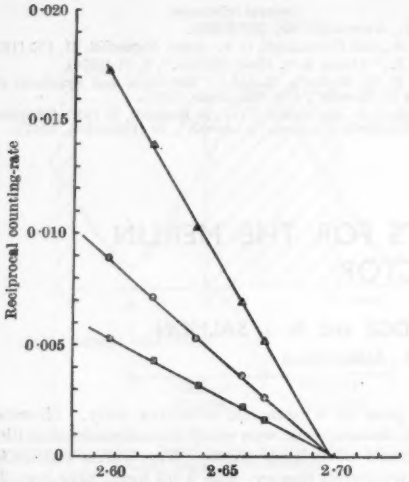

Fig. 2. Approach-to-critical curves: loading 6. Least-squares critical masses:
⊙ counter 1, 2698·5 ± 0·5 gm.; ⊡ counter 2, 2700·1 ± 0·9 gm.;
△ counter 3, 2698·3 ± 0·9 gm.; mean, 2699·0 ± 0·6 gm.

added to complete the assembly of fuel and moderator. A neutron source, emitting about 10^6 neutrons/sec., is fixed in the lattice plate, and three neutron counters are arranged at suitable positions outside the core. The sub-critical core acts as a neutron multiplier; the multiplication increases the closer the system approaches to critical, at which point it becomes infinite. This is the basis for the well-known method of measuring critical masses by the approach-to-critical technique. If the reciprocal of the counting-rate is plotted against the mass of fuel in the core the critical mass can be obtained by extrapolation to zero. A limit on the maximum reproduction factor of 0·998 was set for the experiments reported here.

The apparatus has several safety features and an electrical interlock system enforcing a logical and safe sequence of operations. For example: fuel cannot be loaded unless water from the core tank has been drained to a dump tank and two safety elements are inserted in the core; instrumentation must be functioning correctly before the safety elements can be raised; water can only be pumped into and retained in the core tank if the safety elements are raised ready for action. Stringent rules are enforced regarding permissible increments of fuel and the amount of fuel issued for a particular experiment.

Apart from the interlocking system, a shut-down can be initiated by a γ-ray monitor set to operate at a low radiation-level or by any of the neutron counters. The trip settings for the latter are adjusted after each change in the core to allow a small margin above the predicted neutron counting rates. On a shut-down, both safety elements fall independently by gravity into the core and two separate valves are released to drain the tank of water. Means are provided for securely clamping the reactor control elements in the core during a measurement of their effectiveness in terms of additional uranium-235 for criticality.

A number of measurements of critical mass have been made. The minimum critical mass for a compact core of 5 × 4 elements was found to be 2656·7 ± 1·5 gm. uranium-235, in satisfactory agreement with the calculated values. In the reactor, the minimum working critical mass will be slightly larger, since, for safety reasons, the control and safety elements are not completely disengaged from the core when in their fully withdrawn position. To measure the effect of the elements it was therefore necessary to determine first a datum critical mass with one coarse element, one fine element and two safety elements in the withdrawn position. As an example of the experimental results, the approach-to-critical curves obtained in this measurement are given in Fig. 2; the particular core assembly is shown in Fig. 1. The result indicates that the withdrawn control units will have an effect corresponding only to a few grams of uranium-235. The original design of fine control element (a strip of cadmium sealed in stainless steel) was modified after a measurement with the element clamped in the core had shown that the effect was considerably greater than that desired. The fine unit for the reactor will now be a plain strip of stainless steel, 1·25 in. wide by 0·125 in. thick. Other experiments have shown that the design of the coarse control units, each of which contains a total area of 275 in.^{2} of cadmium sheet, 0·047 in. thick, clad in stainless steel, is satisfactory.

When the fuel elements are in the reactor, a ring-shaped antimony–beryllium neutron source will be attached to the spigot of each element. The purpose of the sources is to maintain the reactor power when shut down at an observable level (about 2 mW.) so that the behaviour of the reactor can be monitored continuously. Provision of one source per element ensures that this safety feature cannot easily be removed. Apart from the consideration of providing neutrons for the core, the position of the sources was chosen so that they should be self-regenerating during operation of the reactor (antimony-124 with a half-life of 60 days being produced by neutron capture), but cause negligible increase in the critical mass. This latter effect has been checked by measuring critical masses with and without inactive sources attached to each fuel element.

Table 1 summarizes the critical mass measurements which have been made. The effect of impurities in the water (conductivity 25 μmho. cm.$^{-1}$) on the critical masses determined is calculated to be about 10^{-3} of the experimental errors. These experiments have given valuable information for the first start-up of the reactor; further experiments are in progress relevant to the use of the reactor at power;

Table 1

Loading	Objective of experiment or core arrangement (temp. 25° C.)	Critical mass uranium-235 (gm.)
1	Preliminary experiment to find optimum geometry for counters and a satisfactory sequence of loading fuel elements	—
2	No control elements present	2691·5 ± 3·1
3	Datum critical mass with fine-control element *and* coarse-control element in OUT position	2701·2 ± 1·6
4	Fine-control element in IN position	2904·0 ± 2·0
5	Reactor neutron sources attached to each element (21 in all)	2700·8 ± 1·3
6	Modified stainless steel fine-control element, 4 in. wide, and coarse-control element in OUT position	2699·0 ± 0·6
7	4-in. fine-control element in IN position	2831·9 ± 1·8
8	1¼-in. fine-control element in IN position	2754·9 ± 0·8
9	Coarse element No. *C3* in IN position	3558·8 ± 7·1
10	Coarse element No. *C4* in IN position	3538·9 ± 2·1
11	1¼-in. fine-control element *and* coarse element No. *C4* in IN position	3586·9 ± 2·1
12	Coarse element No. *C3 and* coarse element No. *C4* in IN position	4148·1 ± 8·4

for example, the study of temperature effects, the determination of critical sizes of cores with air or water voids, such as may be used to provide irradiation facilities within the core itself, and the measurement of thermal neutron flux distributions in the core.

We are indebted to Brigadier I. H. Reeve and Mr. R. S. Curtis for assistance with the experiments, and to Miss B. Clarke and Mrs. M. Stephens for the necessary computational work. We also wish to thank Dr. T. E. Allibone for his interest in this work and for permission to publish this paper.

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EXPLORER (SATELLITE 1958α) OVER AFRICA

By Dr. DAVID S. EVANS
Royal Observatory, Cape Province, South Africa

WHEN proposals for launching artificial satellites were first mooted by the Americans, it was realized that South Africa, the first considerable land mass over which a satellite launched from the southern part of the United States would pass, had special opportunities for making observations. Accordingly, plans were made for the installation of a Baker–Nunn tracking camera, 'Minitrack' stations, and visual stations on the 'Moonwatch' plan. In the event, these last have, up to the present time, produced a considerable part of the tracking data obtained.

Four 'Moonwatch' stations have been established, at Johannesburg, at Pretoria, at Bloemfontein and at Cape Town. These were first equipped with the ordinary 2-in. 'Moonwatch' telescopes, for which the optical components were presented by the South African Council for Scientific and Industrial Research as part of its contribution to the International Geophysical Year. Teams of amateur observers with a stiffening of professionals from the observatories at the four centres were organized. Communications facilities in the form of teleprinter machines connected to the Cable and Wireless Office in Cape Town were provided by the South African Post Office. A visual co-ordinator (the present author) was appointed by the South African National Committee of the International Geophysical Year to concert the efforts of the teams.

The organization had to be modified when the Russian Earth satellites were launched, but a considerable number of observations of these has been obtained, the Johannesburg team being especially active. Towards the end of 1957, it was arranged that the teams at Cape Town and Bloemfontein should be equipped by the U.S. Naval Research Laboratory with 5-in., so-called 'apogee', telescopes. Forty-nine such telescopes, complete with mountings, were supplied to each of the stations at Cape Town and Bloemfontein. However, owing to manning difficulties at the latter station, ten instruments have now been transferred to Johannesburg.

Installation of this equipment was in progress when *Explorer* (Satellite 1958α) was launched on February 1, and at all stations there were heroic improvization and effort. An idea of the scale of the work involved may be gained from the log of the Cape Town team, which recruited about 130 observers, and, between February 2 and February 22, mounted sixteen watches in the small hours of the mornings with an average complement of 20–25 observers. These efforts were rewarded on the morning of February 8, when the Cape Town team made the first sighting of *Explorer* outside the United States.

Table 1. South African Observations of *Explorer* (1958α)

Cape Town: long. 18° 28′ 38″ E., lat. 33° 56′ 00″ S.; height, 10 metres

Date	U.T.	Altitude	
8.2.58	02h. 54m. 34·0s.	72° 20′ N.	Offset
10.2.58	02 45 19·8	79 24 N.	,,
12.2.58	02 35 37·6	84 00 N.	,,
14.2.58	02 25 27·2	85 36 N.	,,
15.2.58	03 21 17·0	76 00 N.	,,
16.2.58	02 14 56·8	82 55 N.	,,
26.2.58	20 03 01·8	41 00 N.	Meridian: very difficult through cloud
3.3.58	18 37 16·2	66 15 N.	Offset
7.3.58	18 10 07·0	82 50 N.	,,
8.3.58	19 05 02·8	82 45 N.	,,
10.3.58	(18 51)	79 15 N.	Not timed: inexperienced observer
14.3.58	18 19 26·3	67 39 N.	Offset: Magnitude 10
15.3.58	19 13 23·1	37 00 N.	,, Magnitude 8

Johannesburg

Mr. Overbeek's Observatory: long. 28° 08′ 26″ E., lat. 26° 11′ 42″ S.; height, 1,708 metres

Date	U.T.	R.A. (1950)	Declination (1950)
13.2.58	01h 31m. 57·8s.	12h. 53m. 22s.	− 71° 55′
11.3.58	17 43 39·6	06 52	− 62·8°
14.3.58	18 22 18·4	07 47	− 32·7 Mag. 9

Union Observatory: long. 28° 04′ 30″ E., lat. 26° 10′ 55″ S.; height, 1,806 metres

20.2.58	01h. 55m. 29·5s.	13h. 45·8m.	−49° 38′	Mag. 8+
2.3.58	17 45 05·6	06 19·4	−46 50	,, 9½
3.3.58	18 39 41	07 48·9	−74 04	,, 10
4.3.58	17 32 05·5	06 22·0	−56 2	
7.3.58	18 12 33	07 01·5	−71 38	
12.3.58	18 37 28	Altitude 69·5° S.	Meridian	
18.3.58	17 50 36·0	07 25·8	−04 16	,, 8·5 or brighter
20.3.58	17 34 11·0	07 15·0	+07 30	,, 9
22.3.58	17 17 18·0	07 08·9	+18 03	,, 10

Bloemfontein

Long. 26° 13′ 36″ E., lat. 29° 06′ 20″ S.; height, 1,634 metres

Date	U.T.	Altitude		
21.2.58	02h. 50m. 49·8s.	46° 42′ N.	Offset	
23.2.58	02 39 38	30 06 N.	,,	Magnitude 8
25.2.58	02 28 12±2	17 54 N.	,,	
26.2.58	18 09 21·6	43 06 N.	,,	
28.2.58	17 57 12	63 06 N.	,,	
2.3.58	17 44 34	83 06 N.	,,	
7.3.58	18 12 06	60 30 S.	,,	
16.3.58	18 06 03	69 30 N.	,,	Magnitude 6
20.3.58	17 33 27	49 00 N.	,,	
22.3.58	17 16 33	40 40 N.	,,	

Pretoria

Long. 28° 12′ 43″ E., lat. 25° 43′ 43″ S.; height, 1,311 metres

Date	U.T.	R.A. (1950)	Dec. (1950)
22.3.58	17h. 17m. 19·4s.	07h. 08m.	+17° 18′ Mag. about 9

A second sighting was made on February 10, and these two, together with nine other visual sightings, were made the basis of the first orbit deduced mainly from visual observations. Before this, some predictions based on radio data had been communicated, and the rather high accuracy attained is presumably to be attributed to the high frequency—108 Mc./s.—of the transmitters.

Since these early days, as continuous a watch as possible has been kept to preserve contact until the tracking camera and 'Minitrack' stations could come into full operation. From now on, for a period of a few weeks, it is expected that there will be a lull in South African observing during the period when transits in the area will take place in daylight.

At the present time the inclination is about 33°, so that *Explorer* is always seen north of Cape Town. The prediction of the expected altitude of transit at close approach is often very tricky, since small changes in the estimated height and latitude difference produce large changes in expected altitude. On the other hand, relatively inexact observations near the zenith give good values for the co-ordinates of the sub-satellite point. The present value of the period, about 114·7 min., gives 25 circuits in a few minutes short of 48 hr., so that once an observation has been secured, it is possible to predict future transits on alternate days with some success.

The satellite is, of course, much fainter than the Russian Earth satellites, and, with one exception, no magnitude reported from South Africa has yet been brighter than 8, while observations down to 10th magnitude have been recorded. The elongated shape evidently causes considerable changes in brightness at different aspects, and it is not uncommon for the satellite to be missed on occasions when it is certain from other evidence that a transit has occurred in the part of the meridian under observation, and when conditions are otherwise excellent.

Table 1 comprises the South African observations made so far; the note 'Offset' refers to the fact that the apogee telescopes have a cross-wire offset by 0·4° to the east of the meridian, and that the timing refers to transit over this wire.

Multiple observations of the same transit from the same place have been meaned.

RECORDING TELEVISION PICTURES ON MAGNETIC TAPE

DURING the past two years, the B.B.C. Research Department has been developing a new technique for recording the pictures used in television broadcasting. The results of this work were seen in some very satisfactory demonstrations during April 8–10 at the Nightingale Square laboratories of the Department. Dr. P. E. Axon, head of the team responsible for this successful development, explained that this new Vision Electronic Recording Apparatus (already known as VERA) uses the electrical impulses forming the video signals to operate on magnetic tape of the ordinary type used for sound recording.

On account of the much higher frequencies used in television signals, the tape speed has been increased in the present equipment to 200 in. a sec.; and a special mechanical arrangement is provided to ensure that a loop of tape is drawn past the recording head at a constant speed. The tape is half an inch wide, and passes in succession under separate recording and reproducing devices which operate on three tracks, two for the vision signals and a third for the accompanying sound. Each of these devices comprises three identical magnetic heads separated from each other by copper screens. The recording heads provide the magnetic field transferring the signals to the tape, and the separate reproducing heads enable the signals to be continually monitored by viewing while the recording is in progress.

In the early stages of the electronic equipment, the video signal, which covers a band-width of 3 Mc./s., is split into two frequency bands of 0–100 kc./s. and 100 kc./s–3 Mc./s. The difficulties normally associated with the recording of very low frequencies at high tape-speeds have been overcome by using the 0–100 kc./s. signals to modulate a carrier of 750 kc./s., and recording this frequency-modulated carrier on one track. In reproduction, the amplitude-limiting facilities associated with the reception of frequency-modulated signals are used to eliminate any undesired fluctuations in amplitude due to the tape or recording process. The higher band of video signals from 100 kc./s. upwards is recorded simultaneously on the second track in the conventional manner. In reproduction, the two sets of video signals are recombined in the later stages of the electronic equipment.

To avoid the corresponding difficulties in recording the sound signal at low frequency, this signal is imposed as a frequency-modulation on a carrier of 100 kc./s., which is then recorded on the third track. On reproduction, this carrier is limited and demodulated to provide an audio signal of high fidelity exactly synchronous in time with the video signals reproduced from the other two tracks.

After a brief explanation of the main technical features of the equipment described above, Dr. Axon and his colleagues showed the reproduction of a recorded programme on a normal television receiver. This was followed by a very satisfactory demonstration given with two receivers side by side. The first displayed the results of the direct reception of television by radio, while the second presented the reproduction of the same signals as they were recorded on the machine and picked up immediately from the reproducing head. It was thus possible to see the same pictures with an interval of 1/25 sec. between them; this time corresponding to the passage of the tape under the recording and reproducing heads, respectively. This demonstrated one of the most important features of the apparatus, which is the immediate availability of the recorded programme without the delay accompanying the photographic process when the recording is done visually on film. Another advantage is associated with the economy of magnetic tape as compared with photographic film. An erase head is fitted to the recorder so that an unwanted programme can be removed from the tape, which is thus available for later use.

An interesting illustration of the versatility of the new equipment comprised the recording of some of the speakers at the demonstration, and the reproduction of these pictures on the television screen a

few minutes later. The reproduced pictures were in all cases of high quality, and it is clear that this new British system has materially advanced the technique of television and will have important applications. No difficulty is foreseen in extending the technique to colour television when this is brought into service. In the meantime, following these very successful demonstrations, one of these equipments is to be taken into use in the B.B.C. television studios for trial during normal programme transmissions, and some viewers may have already witnessed its inclusion in a recent 'Panorama' programme.

OBITUARIES

Lieut.-Colonel Mervyn O'Gorman, C.B.

MERVYN O'GORMAN, who died on March 16 at the age of eighty-six, should be recognized as one of the great pioneers of the application of science to aeronautics, but there are few now left who remember his outstanding work during 1909–16. In 1909 there was practically no science of aeronautics; no scientific principles of design; and there were no reliable British aircraft engines. Executive officers in high positions had no conviction that aeroplanes would ever be of real military value. But Haldane, who was then Secretary of State for War, made up his mind that "science should come first". He set up the Advisory Committee for Aeronautics, with Lord Rayleigh as chairman. His next step was to offer a part-time appointment as superintendent of the existing Army Balloon Factory to O'Gorman, who was by then a well-known consulting engineer, and a partner in the firm of Swinburne, O'Gorman and Baillie. Haldane made him a member of the Advisory Committee, directing him to act on their advice, and also gave him the right of direct access to himself. O'Gorman was directly responsible to the Master General of Ordnance, Sir Charles Hadden, who was also made a member of the Advisory Committee, where he came into contact with some of the most distinguished scientific men of the day. Hadden got infected with the scientific spirit, and became a warm supporter of O'Gorman in his endeavour to promote large-scale experimental work at Farnborough on aeroplanes and engines in order to supplement and extend the experiments on models at the National Physical Laboratory. So everything went swimmingly at first. The Balloon Factory was soon changed out of all recognition; it became the Army Aircraft Factory in 1911, and the Royal Aircraft Factory in 1912. The numbers employed rose from the original 100 to 2,000 at the beginning of the First World War in 1914. O'Gorman soon gathered around him an exceptionally able group of young men, many of whom have since become famous in industry and science. He inspired them with his energy, good judgment and boundless enthusiasm.

It was under O'Gorman that the long series of skilled researches on the safety of aircraft, which have set a standard to the world, was begun. It was at the Factory that the young Geoffrey de Havilland found the opportunity that led him to fame as a designer; it was there that E. T. Busk studied the stability of aircraft, and designed and flew, without touching the controls, the first stable aircraft in September 1913. It was at the Factory, too, that a young Cambridge physiologist, Keith Lucas, revolutionized compass design, at a time when the vagaries in cloud of the flat compass of naval design were attributed to mysterious magnetic forces. I only mention a few of the revolutions in the science of aeronautics the origin of which can be traced back to the work of the Royal Aircraft Factory in O'Gorman's time.

After Haldane left the War Office, O'Gorman had no firm Ministerial backing. Criticisms of the Factory mounted. O'Gorman was accused of competing unfairly with private aircraft firms. There was no truth in this; all the results of experimental work were communicated freely to industry. The design of experimental aircraft, at that time, was a necessary final test of the soundness of conclusions reached by research. The Factory was not a factory in the real sense of the word; it was, as it now is, an experimental establishment. Thousands of the machines designed at the Factory were constructed by outside firms. But a fierce attack, made in the House of Commons in 1916, led to the appointment of a Committee of Inquiry. The Committee recommended that the Factory should cease to engage in the production even of prototype experimental aircraft, and that O'Gorman's appointment, which was originally for a term of seven years, should not be renewed. He was made consulting engineer to the Director-General of Military Aeronautics, a position of no authority and of little influence. No wonder he felt bitter about his treatment. He made mistakes and enemies, of course, as anyone might, in his position, who tried to make anything. It is sad that he never received the public recognition that was his due.

After the War, O'Gorman did not return to private practice. He busied himself with a variety of voluntary work. He retained his remarkable physical and mental energy to an advanced age. He was always interesting and interested, especially in the doings of his 'young men'. He had a marked artistic talent. He loved making lacquer, and engraving. He lived for some sixty years in the house which he had bought when he married Florence Catharine Rasch in 1897. She died in 1931. They had no children, so there is no one to follow him. But he will always be remembered with affection by the friends who knew him well, and worked with him.

H. T. TIZARD

Dr. Maxwell Garnett

DR. MAXWELL GARNETT, principal of the College of Technology, Manchester, during 1912–20, and secretary of the League of Nations Union during 1920–38, died at Seaview, Isle of Wight, on March 19 at the age of seventy-seven.

James Clerk Maxwell Garnett was born at Cambridge in 1880, the son of William Garnett, who had been a colleague of James Clerk Maxwell. Maxwell Garnett was educated at St. Paul's School and Trinity College, Cambridge, where he was a major scholar, Smith's prizeman and Sheepshanks exhibitioner. He was placed in the first class of Division 1 of the

Mathematical Tripos, Part II, and in 1905 was elected a Fellow of Trinity. In 1903 he was lecturer in applied mathematics at University College, London, and during 1904–12 was examiner to the Board of Education. In 1912 he became principal of the College of Technology, Manchester (then called the Municipal School). On resigning from this post in 1920, he was appointed secretary of the League of Nations Union, which he served until 1938.

Maxwell Garnett was a big man. Well over 6 ft. in height and built in proportion, he was endowed with great natural gifts of body and mind, which enabled him to row in the University trial eights at Cambridge, and at the same time to gain some of the highest mathematical honours. His early original papers on "The Colours in Metal Glasses and in Metallic Films", published in the *Philosophical Transactions of the Royal Society*, amply show the qualities of mind of the authentic mathematical physicist—mathematical power and physical insight; these had been combined, as he said himself, with a happy flash of inspiration which came to him as he was examining some coloured wine glasses on a dining table. The wide range of his interests is indicated by these early scientific papers and his many other publications on psychology and education, particularly "Education and World Citizenship", an essay towards a science of education, a great work of 515 pages published in 1921. He used to say that much of his hard thinking while he was with the Board of Education was done while travelling to and fro on the underground railway. During 1941–44 he was chairman of the British Association Committee on Post-War University Education; its report was prefaced by Sir Richard Gregory, then president of the Association.

His excess of physical energy he worked off through his love of the mountains and the sea. A visitor to his home at Seaview was in no danger of being allowed to relax. As the steamer neared the pier, instead of the normal disembarkation he would see approaching, powerfully stroked by Garnett, a Canadian canoe into which he would be invited to lower his person and luggage, to be whisked away to a small landing stage near Garnett's house; and early the following morning he would be expected to join his host for a swim. In his Manchester days, with the mountains and sea far away, Garnett was often to be seen before breakfast running around Victoria Park with the zest of a man training for a race. Such indeed he was, training his great abilities, guided and controlled by high Christian principles, to serve the cause of education and the human race.

He had many of the qualities of the great leader. No one who worked with him could fail to admire the zeal and devotion with which he applied himself to the task in hand, or fail to gain something positive from his example. If he appeared somewhat intolerant to a few who could not see so far ahead or keep up the pace he set, this could perhaps be explained by his own modesty, which would not allow him to admit that the energy and foresight of others might fall short of his own.

His high principles caused him to resign his principalship in 1920 when he did not see eye to eye with the Manchester Education Committee, which had decided to confine the university side of the College of Technology within limits which Garnett regarded as too narrow to meet the coming needs of the country for trained technologists. An example of his forward-looking qualities was his appointment of Murray Wrong, of Oxford, as vice-principal to help "to civilize the technical students". In recent years he no doubt followed with pleasure the rapid extensions that have been taking place and plans for further extensions. These were foreseen during his period of office, for the *Manchester Guardian* pointed out that "Mr. Garnett in addition to the ordinary labours of post-war reconstruction, had been the chief instrument in the collection of some £130,000" intended to further the growth of the College.

Again, in 1938, having devoted all his powers to the ideals of the League of Nations Union, his principles compelled him to resign the secretaryship when he feared that the Union might be "used as an instrument of political propaganda".

Garnett was very happily married to Margaret Lucy, gifted, generous and warm-hearted, the second daughter of Sir Edward Poulton; she, three daughters and three sons, survive him. F. Bowman

Mr. O. T. Faulkner, C.M.G.

Odin Faulkner's career was one of great promise, fine achievement and deep disappointment. He distinguished himself at St. Albans School by gaining the Hertfordshire County Agricultural Scholarship and a major scholarship to Caius College, Cambridge. He had a brilliant university career, graduating with first-class honours in the Natural Science Tripos in 1911 and obtaining the diploma in agriculture in 1912.

After two years with the Rubber Growers' Association, Malaya, he joined the Indian Agricultural Service as deputy director of agriculture, Lyallpur, Punjab.

In 1921, at the early age of thirty, he was appointed to the important post of Director of Agriculture in Nigeria, and it was in that country that he achieved fame. He clearly saw that the traditional system of shifting cultivation could not long sustain an increasing population, and observed that soil fertility had fallen to a dangerously low level in large sections of the country. He concentrated the efforts of his Department on devising means of maintaining soil fertility under permanent systems of cultivation. He created consternation in Government circles by demanding a breathing space of ten years in which to solve this major problem. He inspired his staff with his own enthusiasm, and by patient team-work they evolved a system of mixed farming for the Northern Province and green manuring for the Southern Province.

He accepted transfer to Malaya in 1936, with some reluctance, but welcomed his appointment to the post of principal of the Imperial College of Tropical Agriculture in the West Indies in 1938. Here, he felt, was a challenge worthy of his mettle. The forthcoming visit of the West India Royal Commission appeared to offer a unique opportunity of enabling the College to fulfil its real destiny. In close collaboration with his colleagues, he drew up a long-term programme of development. The outbreak of war, in 1939, deferred indefinitely the implementation of this programme, and denied him what would have been the crowning achievement of his career.

Although Faulkner carried out his duties with efficiency and led the staff in numerous voluntary activities in furtherance of the war effort, his work had lost its savour. He retired in 1946 and spent his first winter in England helping to build the yacht, *Chantek*, which became the home of the

Faulkner family, until a most unfortunate accident impaired the use of his hands and compelled him to abandon the sea and settle ashore.

Faulkner had simple tastes and detested formality. He was never at home in large gatherings, and his shy, modest and retiring disposition created the false impression that he was not approachable. In fact, there was nothing he relished more than a full pipe and a free and informal discussion. His wife, Mildred, gladly abandoned her distinguished career as a surgeon to share with Odin such pleasures as tennis, golf, bridge, gardening, country walks and yachting. His retirement enabled them and their sons to enjoy to the full the graceful ease and deep contentment offered only to a thoroughly united family.

C. Y. SHEPHARD

Prof. H. King

PROF. HERBERT KING, professor of geography in the University of Hull, died on March 1 after a long and courageous struggle against failing health. He will be remembered at Hull as founder of the Department of Geography, for his devotion to University affairs, and in a wider field as a human geographer in the tradition of his old teacher, Prof. P. M. Roxby.

Herbert King was born in 1897 and educated at Wigan Grammar School, where in 1915 he was head boy and Powell Scholar. After three years war service in the Sherwood Foresters, during which he was wounded in France, he studied geography at the University of Liverpool, securing first-class honours, and was appointed successively to a University scholarship, a University fellowship, and a lectureship in geography in 1924. During this period he studied the evolution of the industrial and agricultural complex of Lancashire and Cheshire, and his published work included contributions to the "Lancastria" section of "Great Britain: Essays in Regional Geography".

In 1928 he was appointed the first lecturer in geography in the newly founded University College of Hull, and for the next few years he taught single-handed the entire geography syllabus for the University of London external degree examination, at the same time laying the foundations of what is now a flourishing Department with an honours school of nearly a hundred. Other activities during the 'thirties were the organization of the Land Utilization Survey of the East Riding, and a period as joint secretary and later recorder to Section E (Geography) of the British Association.

During the Second World War, Prof. King worked at the Board of Trade and the Ministry of Information, and on return to University life became deeply involved in the post-war expansion of the College, which included the development of a geological section, initially as a branch of his own Department. His experience involved him in much committee work, notably as chairman of the Library Committee (1947–52) and as dean of the Faculty of Science (1952–54). He was also president of the Hull Branch of the Geographical Association (1947–54).

In 1954, when the College received its charter as a University, he was appointed its first professor of geography. He spent the session 1954–55 as visiting professor in the University of Rochester, U.S.A.; soon after his return he showed signs of ill-health, but for the next two years, despite an obvious worsening, he willed himself to work almost to the end. Early this year, however, he became gravely ill, and he died at his home on March 1.

King published little, but his memorial is the Department which he built up, for many years under conditions of great financial stringency. He remains, to all who knew him, an example of absolute integrity, and of loyal devotion to the College and University which he served for thirty years. He married in 1926 Helen M. Ashcroft, who survives him.

L. F. PENNY

NEWS and VIEWS

Linnean Society of London: Awards

THE Council of the Linnean Society of London has nominated Sir Gavin de Beer and Dr. W. B. Turrill for the award of Linnean Gold Medals for 1958; normally, only one is awarded annually, to a botanist or zoologist alternately, but the centenary of the reading before the Linnean Society of the joint communication by Darwin and Wallace on evolution by natural selection is being marked by the presentation of two Gold Medals, to a zoologist and a botanist respectively. The presentation will be made at the anniversary meeting on May 24, 1958.

In commemoration of the centenary the Council of the Society has also nominated the following for the award of a Silver Darwin–Wallace Commemorative Medal in recognition of their outstanding contributions to our knowledge of evolution. The Medals will be presented at a special meeting of the Society to be held at the Royal Geographical Society on July 15: Dr. Edgar Anderson (U.S.A.), Prof. Maurice Caullery (France), Sir Ronald Fisher (Great Britain), Prof. C. R. Florin (Sweden), Prof. J. B. S. Haldane (Great Britain), Prof. Roger Heim (France), Dr. John Hutchinson (Great Britain), Sir Julian Huxley (Great Britain), Dr. Ernst Mayr (U.S.A.), Prof. H. J. Muller (U.S.A.), Prof. E. Pavlovsky (U.S.S.R.), Dr. Bernhard Rensch (Germany), Dr. G. Gaylord Simpson (U.S.A.), Prof. Carl Skottsberg (Sweden), Prof. E. A. Stensiö (Sweden), Dr. H. Hamshaw Thomas (Great Britain), Prof. G. V. Turesson (Sweden), Dr. V. van Straelen (Belgium), Prof. D. M. S. Watson (Great Britain) and Dr. J. C. Willis (deceased).

Metallurgy at Cambridge: Prof. G. W. Austin

THE impending retirement of Prof. George Wesley Austin from the Goldsmiths' chair of metallurgy in the University of Cambridge presents an occasion for directing attention to the remarkable growth in metallurgical activity that has taken place during his occupancy of the chair. While the Department of Metallurgy has had a separate existence for many years—it was founded in 1888—the situation of Cambridge, away from the centres of the metallurgical industries, has tended to militate against any great development there in the teaching of the more practical aspects of the subject. The rapid widening

of interest in the properties of metals and the unexpected importance of many of the less-known elements, the metallic properties and behaviour of which had not been studied, have stimulated a rapid development in the scientific aspects of metallurgy since the Second World War. Prof. Austin was appointed to his chair in 1945 and came from the Royal Naval Scientific Service. Trained at the University of Sheffield and in the famous metallurgical school at Aachen under Prof. Goerens, his interest has always been in the engineering side of the subject—particularly in those properties of materials that found an engineering application. His appointment was appropriately timed and his outlook and energy combined to foster a rapid growth of the Department. The already cramped space soon proved too small for the numbers of students who wished to read metallurgy for their final Tripos examination and for those engineers who were becoming more metallurgically minded. Even with an allocation of extra space, a state of overcrowding has persisted, illustrating the success of Prof. Austin's teaching. From one of the smallest metallurgical departments in Britain, that at Cambridge has grown to be one of the largest and best-equipped. Prof. Austin has always been painstaking in all matters of detail and had a wide knowledge of the world's metallurgical practice at instant command. His students will regret the retirement from the University of one who was a friend to them all and whose human sympathy for their difficulties went more than half-way to removing them.

Prof. A. H. Cottrell, F.R.S.

Dr. A. H. Cottrell, deputy head of the Metallurgy Division, Atomic Energy Research Establishment, Harwell, has been appointed to the Goldsmiths' chair of metallurgy in succession to Prof. G. W. Austin. A note on Dr. Cottrell's work was published in *Nature* (**175**, 495 ; 1955).

Engineering at Saskatchewan : Dean I. M. Fraser

Dean I. M. Fraser, who is shortly to retire as dean of the College of Engineering, University of Saskatchewan, graduated in 1919 at McGill University, and after a period in industry was appointed assistant professor of mechanical engineering in the University of Saskatchewan. He became head of the Department of Mechanical Engineering in 1937 and was then appointed dean of the College in 1953. Dean Fraser was vice-president of the Engineering Institute of Canada during 1953–54 and is a past-president of the Association of Professional Engineers of Saskatchewan.

Prof. A. Porter

Prof. A. Porter, who has since 1955 held the chair of light electrical engineering in the Imperial College of Science and Technology, London, has been appointed dean of engineering in the University of Saskatchewan and will be taking up this post in September. In returning to Canada, where he resided for seven years previously to his appointment in London, he has been influenced by special circumstances concerning the health of his family, and he will be greatly missed in England. In recent years, Prof. Porter has become widely known for his imaginative approach to the use of symbolic logic in application to engineering problems. He has greatly stimulated thought in Britain on the application of multi-valued logic and has interested himself in its relationship of logical calculus to the steps by which human beings find solutions to logical problems as well as its application to such practical problems as railway signalling. Prof. Porter has also contributed, during his short period in London, to a new development in engineering education by the establishment at the Imperial College of a mathematics laboratory. This he has developed as an adjunct to engineering courses to provide for training in the use of mechanical calculating machines and to familiarize students with the elements and principles of analogue and digital computing. He has shown that acquaintance with physical devices and models that illustrate mathematical relationships is a valuable aid to the teathing of mathematics as well as to the understanding of practical tools for mechanizing computation.

Mathematics at the University of Exeter : Prof. T. Arnold Brown

Prof. T. Arnold Brown retires in September from the chair of mathematics in the University of Exeter after thirty-five years of devoted service to university education in the south-west of England. He went to Exeter in 1923 from University College, London, on his appointment as the first professor of mathematics in what was then the University College of the South West of England. He had been a pupil of E. T. Whittaker at Edinburgh and E. W. Hobson at Cambridge, and had already made important contributions to analysis, in spite of the interruption of his studies caused by the First World War. During the succeeding years, while maintaining his interest in research, he devoted most of his energies to building up from very small beginnings a strong and well-balanced mathematics department. In 1947 a second chair, that of applied mathematics, was created in the Department, and Prof. Brown was then able to concentrate his attention on developing the pure mathematics side of the honours school, for which he set and maintained a high standard worthy of a modern university ; at the same time he did much to encourage research, and his Department has had a distinguished record of original work. Outside his own Department he also played a great part in helping the College achieve its present university status. He was dean of the faculty of science during the period 1929–33, which was a formative period of expansion and re-organization, not as intensive as that now in progress, but one which laid the foundations for later success. Prof. Brown has also taken a great interest in the teaching of mathematics in schools ; for several years he was on the Council of the Mathematical Association and until recently was president of the local branch of the Association. All will wish Prof. Brown a long and happy retirement.

Prof. David Rees

Mr. David Rees, who has been appointed to the chair of pure mathematics at Exeter in succession to Prof. Brown, is a Fellow and director of studies in mathematics at Downing College, Cambridge, and a member of the Faculty Board of Mathematics of the University of Cambridge. He was educated at King Henry VIII Grammar School, Abergavenny, and Sidney Sussex College, Cambridge, where he was elected successively to an exhibition, a major scholarship and a B.A. scholarship. Mr. Rees obtained a first-class in Part I of the Mathematical Tripos and he was a wrangler in Part II. During the War he worked in Government Communications Head-

quarters. He has made extensive and important mathematical contributions on semi-groups, non-associative algebras and the theory of commutative rings.

Prof. A. T. Price, of the chair of applied mathematics, succeeds Prof. Brown as head of the Department of Mathematics at Exeter.

Chemical Pathology at Cape Town : Prof. J. E. Kench

Dr. James E. Kench, who has recently been appointed to the chair of chemical pathology in the University of Cape Town, received his early scientific training in the University of Bristol, where he graduated in chemistry in 1933. His first research interests were in plant biochemistry ; and he spent some years at the Long Ashton Research Station, University of Bristol, working under the direction of Prof. T. Wallace. He took the degrees of M.Sc. in organic chemistry in 1935 and Ph.D. in 1938. The following year Dr. Kench went to Manchester, where he was appointed chemical pathologist, and later Sir Halley Stewart Fellow in the Department of Hæmatology of the University and Manchester Royal Infirmary. Some years later he decided to take a medical qualification and graduated M.B., Ch.B. at Manchester in 1950. In 1952 he was appointed lecturer in biochemistry in the Nuffield Department of Occupational Health ; and since 1955 has been senior lecturer in chemical pathology in the University of Manchester. In 1951 he became a Fellow of the Royal Institute of Chemistry. Dr. Kench has made numerous contributions to the subjects of the metabolism of blood, bile and porphyrin pigments, for which he was awarded the D.Sc. of the University of Bristol in 1953. More recently, he has worked on the biochemical effects of heavy metals in general, and the chemical pathology of lead and cadmium poisoning in particular.

Opening of the Brussels International Exhibition

The Brussels Universal and International Exhibition, 1958, the first of its kind to be held since the Second World War, was opened by King Baudouin of the Belgians on April 17. The King, who was accompanied by Prince Albert, King Leopold and Queen Elisabeth, and who spoke in French and Flemish, said that the human race has entered a new era in its history, in which more than ever before civilization appears to depend upon science. Technical progress, however, is not enough ; it must be accompanied by the parallel development of spiritual ideals and the will to achieve together a constructive effort. The Prime Minister of Belgium, M. van Acker, said that the Exhibition's theme of scientific progress gives all the forty-two nations participating a chance to display to the world what they have done to free man and increase his material well-being. The site for the Exhibition covers an area of more than 500 acres on the Heysel Plateau on the outskirts of Brussels (see *Nature*, **180**, 1322 ; 1957). The central exhibit is the 'Atomium', a structure some 360 ft. high consisting of nine steel spheres, each 60 ft. in diameter, joined by steel tubes, to represent the atoms in a metal crystal. In the lower sphere there are exhibits relating to the peaceful uses of atomic energy, and a high-speed lift in the central column leads to a restaurant in the topmost sphere. The International Hall of Science, sponsored by fifteen nations, comprises four sections : The Atom ; The Molecule ; The Crystal ; and the Living Cell. These include displays on nuclear and thermo-nuclear reactions, physics, chemistry and biochemistry, leading up to exhibits on the nature of life.

The Parliamentary and Scientific Committee

The annual report, 1957, of the Parliamentary and Scientific Committee (pp. 21. London : Parliamentary and Scientific Committee, 1958) briefly summarizes the addresses and discussions before the General Committee during the year. These included the scientific and technical aspects of the expanded nuclear power programme ; principles of guided weapons ; the geological survey of Great Britain ; science and technology as applied to the preservation and distribution of fresh food ; mental health to-day ; the present and future of medical research for the tropics ; and problems of aircraft research and development in Great Britain. After the Ministry of Housing and Local Government, Mr. H. Brooke, had indicated, at a meeting with Sir Hugh Linstead, Mr. W. T. Wells and Lieut.-Commander Powell, that nothing could be done regarding the rating of scientific societies before the appropriate legislation, additional information was obtained and the Minister was asked to receive another deputation. As a result of a meeting on July 16, when the Minister told the deputation that he would like further evidence to substantiate the point that the operation of the Scientific Societies Act was "somewhat haphazard", and also as to anomalies with regard to the rating of industrial research, a further comprehensive memorandum was submitted to the Minister directing attention to anomalies in the rating of scientific institutions and research associations. During the second reading debate of the Local Government Bill in the House of Commons on December 9 and 10, 1957, Mr. Brooke announced his intention to set up a committee to give special consideration to the rating of charities and similar organizations, and subsequently he informed the chairman that the terms of reference of this committee would be wide enough to enable it to consider the special position of scientific institutions. A new sub-committee on technological and technical education, with Mr. R. Fort as chairman, was set up during the year.

New Zealand Journal of Geology and Geophysics

In February, the New Zealand Department of Scientific and Industrial Research published the first number of *The New Zealand Journal of Geology and Geophysics*, and from the contents it is evident that the diversity of geology and scenery of New Zealand is well matched by the enthusiasm and industry of her geologists. The thirteen articles (218 pages) cover a wide range of subjects, including a discussion of New Zealand granites and mineralization, Pleistocene geology and geomorphology, and γ-radioactivity and heat flow in geothermal areas. A number of these are likely to appeal to the interests of geologists throughout the world ; for example, a challenge to the turbidity-current theory as an explanation of certain features of graded and banded sediments in a contribution by J. T. Kingma ("The Tongaporutuan Sedimentation in Central Hawke's Bay", pp. 1–30). In the first number the new journal has set itself a high standard of presentation, particularly as regards the clarity of the diagrams and maps, several of which employ two-colour blocks. It will be published in alternate months at a price of 30*s*. per annum (5*s*. for single copies) post paid, and may be obtained

from the Department of Scientific and Industrial Research, P.O. Box 8018, Wellington, New Zealand, or through the High Commissioner for New Zealand, 415 Strand, London, W.C.2, or through any bookseller.

Metallurgist

The papers included in this publication (*Metallurgist*, No. 1; January 1957. Monthly Industrial Technical Journal of the Ministry of Iron and Steel of the U.S.S.R. In English translation. Pp. ii+69. Annual subscription: 95 dollars; single issues: 20 dollars. New York: Consultants Bureau, Inc., 1957) are mainly short, and of widely differing degrees of importance. All deal with the iron and steel industry and are of a severely practical character, in some cases little more than instructions to foremen. The subjects dealt with range over the whole industry, from the charging of the blast furnace to refractories for open-hearth furnaces and regenerators, tube production, galvanizing and the handling of frozen ore. There are, however, one or two contributions of a more substantial nature, of which that on the use of magnesium as a deoxidant in the production of basic Bessemer rail steel may perhaps be particularly cited. Added to the steel in the ladle in the form of a silico–magnesium alloy containing 64 per cent silicon and 12 per cent magnesium, experimental melts are reported in which 2 and 6 lb. of this alloy per ton of steel have been added, together with ferro-manganese and a small amount of aluminium. The mechanical properties of the steel so treated appear to be satisfactory, and it is claimed that the quantity of non-metallic inclusions is appreciably reduced. Perhaps the most interesting feature is, however, the increased toughness, as measured by some form of impact test: at 0° C. the steel treated with the magnesium alloy had a 'resilience' of about 1·7 kgm./cm.^{2}, as compared with about 0·8 for the material treated in the normal way. It may well be that among the practical papers points of interest will be found, but the general impression obtained is of a standard of technique lower than that which is normal in the West.

Technical Change and Industrial Relations

In the first of a new series of booklets, intended to present briefly and simply the results of current research into the social, economic and technical problems of industrial progress, which the Department of Scientific and Industrial Research is commissioning and editing, Olive Banks and Dr. W. M. Scott have summarized the intensive study of technical change in a large British steel-works made by the Industrial Research Section of the Department of Social Science at the University of Liverpool and published under the title "Technical Change and Industrial Relations" (cf. *Nature*, 179, 331; 1957). The booklet (Problems of Progress in Industry, No. 1: Men, Steel and Technical Change. Pp. 36. London: H.M. Stationery Office, 1957. 2*s*.) first outlines the technical changes concerned and their effects on the labour force. Next the problems of management involved and the relations between trade unions and management are described. The attitudes to technical change are summarized and a case study of the melting shop is described before the conclusions reached are outlined and the implications for industry in general indicated. Like the rest of the series, the booklet is planned to assist responsible officials on both sides to digest and use new material, but it is no disparagement of an excellent summary to suggest that no responsible official is likely to stop short of the lucid conclusions of the main report itself.

Domestic Pets

A brief survey by Political and Economic Planning shows that the attractions of domestic pets for British people are undiminished ("Economics of Domestic Pets," 2*s*. 6*d*.). Fifteen million homes in Britain have many domestic pets: dogs, cats, pet mice, hamsters and guinea pigs, rabbits, fish and birds of many kinds. In earlier days the status of pets was in many ways marginal, in that they were often regarded as eaters and snappers up of unconsidered trifles. The position is very different to-day. Total expenditure on pets is more than £50 million a year. The provision of special foods and equipment for pet animals and birds has developed into a considerable activity. Sales of prepared foods for cats and dogs amount to about £10 million a year and now form part of an important industry. Large sums are spent on advertising pet foods of various kinds, while puppies and kittens often rival female charms as suitable material for advertising copy. The Zoological Society of London has received so many requests for advice that it now issues a booklet ("Advice on Pets," 1*s*. 3*d*.) on how to feed, house and care for a wide variety of pets, ranging from foxes and monkeys to chameleons.

Manchester Public Libraries

The annual report of the Manchester Public Libraries Committee for the year ended March 31, 1957 (105th Annual Report of the Libraries Committee, 1956–1957. Pp. 27. Manchester Public Libraries, 1957), records an increase of 75,728 in books consulted in the reference libraries (977,496), and of 89,454 in those lent by the lending libraries (5,632,747). Of the grand total of 1,137,732 volumes, 458,814 are in the reference libraries, where the catalogues now contain 823,987 cards. Increased use was made of the microfilm reader and there was a steady growth in the use of the photocopying services. Readers in the Technical Library increased from 187,465 to 221,351, photocopies from 2,787 to 3,139, special loans to industry from 717 to 1,208, and telephone inquiries from 3,849 to 5,976, while the part played by the Technical Library in education is stressed equally with its services to industry. During the year it was agreed that the Technical Library should also be a depository for open reports on nuclear energy to be issued by the European Atomic Energy Project. The Commercial Library, which received 9,324 telephone inquiries compared with 5,453 in 1953, has compiled an index to statistical publications available in the reference libraries. Two reading lists on the European Common Market were issued, and the Commercial Library now holds 2,243 current directories and takes 574 periodicals.

The Sixteenth-Century Pokom-Maya

The Pokom are a Maya group with two closely related subdivisions, the Pokomchi and the Pokoman. The former hold a small territory in the Alta Verapaz, Guatemala; the latter formerly occupied the eastern highlands of Guatemala, including the present-day Guatemala City, and adjacent parts of El Salvador. Pokom-speaking enclaves still exist, but much of their original culture has been lost. To reconstruct

it, Miss S. W. Miles has drawn on the sources, principally the writings of Las Casas and of his fellow Dominicans, Diego de Zuñiga, Pedro Moran and Thomas Gage, and has recently published a documentary analysis of the social structure and archæological setting of the Pokom-Maya in the sixteenth century (*Trans. Amer. Phil. Soc.*, **47**, 735; 1957). De Zuñiga's vocabulary is a rich mine of information on the culture of the Pokomchi shortly after the Spanish conquest. This is a first-rate piece of difficult research.

Statistics of Smoking

"'STATISTICS OF SMOKING' . . . is the first of a series of Research Papers which will be published from time to time by the Tobacco Manufacturers' Standing Committee as a contribution to research. The subjects of these monographs will be those to which the T.M.S.C. is able, by means of the resources at its command, to make an authoritative contribution." So states the explanatory note attached to an extensive survey (edited by G. F. Todd. Pp. 64. London: Campbell-Johnson, Ltd., 1957) relating to tobacco sales and consumption figures for the United Kingdom and twenty-one other countries. The paper is very welcome, both as a symbol of co-operative effort and for the data presented. Many workers will find these figures fascinating as well as useful, and the substitution of estimates for that which "is notorious, and conspicuous in the memory of most of us" (Fisher, R. A., *Brit. Med. J.*, **2**, 297; 1957) cannot but do good. There is, perhaps, a possibility that the words "authoritative contribution" may lead to too great a reliance being placed on some figures. For example, Table 3 provides figures for the "Consumption of Tobacco Goods by Women in the U.K." yearly from 1920, but no explanation is given as to how the estimates have been made; without such an explanation it is difficult to form an opinion as to their probable accuracy.

Research at the University of Melbourne

BELIEVING that a university has a duty to inform the public-at-large of its activities, the University of Melbourne has issued the second copy of its journal, *Discovery*, which has been designed deliberately for the layman. The first appeared in June 1955 and presented the broad background of research being undertaken in various university departments. The present volume explains in greater detail some twenty research prospects; topics have been chosen as much by their possibility of clear exposition as by their intrinsic importance to the general reader. All topics are included under the five headings: discovery in medicine, in science, in the humanities, in technology and in the social sciences. They are well chosen, clearly written, and generously supplemented with photographs. A colour plate on the cover of this attractive journal is a reproduction of a mural by Douglas Annand and Tom Bass in one of the university halls. It is a graphic representation of humanity struggling from the chaos of its primitive origins and striving to reach the light of truth as symbolized by the Sun—and will long excite admiration.

National Science Foundation Grants

THE National Science Foundation has announced 409 grants totalling 15,035,656 dollars awarded during the quarter ending December 31, 1957, for the support of basic research in the sciences, for support of basic research facilities, for conferences in support of science, for exchange of scientific information, and for training of science teachers. This is the second group of awards to be made during the fiscal year 1958. During the first quarter, 316 such grants were awarded, totalling almost 5·5 million dollars. Grants announced recently were made to institutions and scientists in the United States, Canada, Britain, Hawaii and Puerto Rico. The research fields included are anthropology, astronomy, chemistry, biology, physics, earth sciences, engineering sciences, mathematical sciences, and socio-physical sciences.

The Royal Society of London

BESIDES a report of an address by the president, Sir Cyril Hinshelwood, in which he defines the aims and functions of the Royal Society of London, the latest issue of *Notes and Records* is mainly devoted to accounts of the life and work of Edmond Halley and Sir Charles Sherrington (**12**, No. 2). Halley is described by Prof. S. Chapman and Sir Harold Spencer Jones, while Sherrington's career and interests are considered in articles by Lord Adrian and J. C. Eccles. A description of the exhibition prepared by the Society to celebrate Halley's tercentenary is given by Sir Edward Bullard and C. A. Ronan. Other articles include one by Prof. Douglas McKie on Bernard le Boivier de Fontenelle and an account of the visit to the U.S.S.R. of the Royal Society delegation in 1956. An admirable word-portrait of J. J. Thomson as they knew him is painted by George and Joan Thomson.

Commonwealth Fund Fellowships

THE Committee of Award of the Commonwealth Fund Fellowships announces the following elections, among others, for 1958–59. *General Fellowships:* C. Green, Liverpool (biochemistry); M. R. House, Durham (geology); T. W. B. Kibble, Edinburgh (physics); H. D. Law, North Staffordshire (chemistry). *Home Civil Service Fellowships:* D. L. Medd, Ministry of Education; J. F. Montgomerie, Ministry of Transport; D. W. G. Wass, Treasury; T. B. Williamson, Ministry of Health. *Oversea Civil Service Fellowships:* J. R. Harries, Kenya (medicine); A. H. M. Kirk-Greene, Nigeria (sociology).

Institute of Metals: Officers

THE following have recently been elected to office in the Institute of Metals: *President*, Marshal of the Royal Air Force Lord Tedder (chancellor of the University of Cambridge; chairman, The Standard Motor Co., Ltd.); *Vice-Presidents*, Mr. G. L. Bailey (director, British Non-Ferrous Metals Research Association); Mr. R. D. Hamer (vice-president, Aluminium Laboratories, Ltd.); and Sir Ronald Prain (chairman, Rhodesian Selection Trust, Ltd., Roan Antelope Copper Mines, Ltd., and Mufulira Copper Mines, Ltd.).

University News: Birmingham

THE following have been appointed to senior lectureships from October 1: Dr. G. E. Brown (mathematical physics), Dr. J. C. Bevington (chemistry), Dr. J. G. Hawkes (botany), Dr. C. W. Nutt (chemical engineering), Dr. E. A. Marsland (dental pathology), Dr. G. H. Thomas (endocrine chemistry). The following have been appointed to lecture-

ships: K. J. Durrands (mechanical engineering), Dr. G. J. Lawson (mining).

Exeter

The following appointments in the University of Exeter have recently been announced: Dr. D. C. Collins, to be senior lecturer in education; Dr. L. H. Long, to be senior lecturer in chemistry; and Dr. J. Wilkinson, to be senior lecturer in botany. The following have also been appointed lecturers: Dr. S. A. J. Tarr, in botany; and Mr. K. Coe, in geology.

London

Dr. G. Chapman, lecturer in zoology at Queen Mary College, has been appointed to the University chair of zoology tenable at Queen Elizabeth College. The title of reader in the University has been conferred on Dr. M. G. Fleming (mineral dressing), and on Dr. H. H. Hopkins (optics), in respect of their posts at the Imperial College of Science and Technology.

The following have been elected to fellowships of the Imperial College of Science and Technology, London: Prof. Emeritus H. V. A. Briscoe, formerly professor of inorganic and physical chemistry at the College; Mr. C. A. Bristow, president of the Imperial College Boat Club; Prof. Emeritus V. C. Illing, formerly professor of geology (oil technology) at the College; The Hon. H. Fletcher Moulton, member of the Governing Body of the College; Prof. Emeritus A. J. S. Pippard, formerly professor of civil engineering at the College; and Dr. S. L. Smith, director of research, British Shipbuilding Research Association.

The Night Sky in May

Full moon occurs on May 3d. 12h. 23m. U.T., and new moon on May 18d. 19h. 00m. The following conjunctions with the Moon take place: May 2d. 09h., Jupiter 2° N.; May 6d. 10h., Saturn 3° S.; May 12d. 15h., Mars 6° S.; May 15d. 00h., Venus 4° S.; May 29d. 14h., Jupiter 2° N. There will be a partial eclipse of the Moon on May 3, invisible at Greenwich. Mercury is too close to the Sun for observation. Venus is a morning star, visible low in the south-east before sunrise, but conditions for observation are not very favourable. It rises at 3h. 25m., 3h. 00m. and 2h. 30m. on May 1, 15 and 31, respectively; its stellar magnitude is about − 3·6. During the month its distance from the Earth increases from 80 to 102 million miles and the visible portion of the apparent disk from 0·600 to 0·718. Mars rises at 2h. 50m., 2h. 15m. and 1h. 30m. at the beginning, middle and end of the month, respectively. It is visible low in the south east before sunrise, but conditions for observation are not very favourable; its stellar magnitude is about + 0·8. Jupiter sets at 4h. 15m., 3h. 20m. and 2h. 10m. on May 1, 15 and 31, respectively; it is near Spica. The stellar magnitude of Jupiter is − 1·9, its distance from the Earth on May 15 being 420 million miles. Saturn rises at 23h. 05m., 22h. 10m. and 21h. 00m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi. Its stellar magnitude is + 0·4 and it is at a distance of 850 million miles from the Earth on May 15. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: May 29d. 22h. 36·1m., 86 Vir. (*D*); May 31d. 01h. 06·5m., 8 Lib. (*D*); May 31d. 01h. 12·1m., α Lib. (*D*). *D* refers to disappearance.

Announcements

Prof. J. Brachet, of the Free University of Brussels, has been awarded the Charles Léopold Mayer Prize for 1957 of the Société de Chimie Biologique, for his work on the location of nucleoproteins within living cells. The Prize, which is awarded annually, has a value of 500,000 francs.

Prof. R. S. Hutton, formerly Goldsmiths' professor of metallurgy in the University of Cambridge, has been awarded the Institute of Metals Medal in Platinum in recognition of his outstanding work in connexion with the science and practice of non-ferrous metallurgy. Dr. J. H. Hollomon, manager of the Metallurgy and Ceramics Research Department of the General Electric Research Laboratory, Schenectady, has been awarded the Rosenhain Medal of the Institute of Metals in recognition of his outstanding contributions to knowledge in the field of physical metallurgy.

The first Hulton Achievement Award has been presented by Sir Edward Hulton to the members of the team at the Atomic Energy Research Establishment, Harwell, who created ZETA. The award, which consists of a silver trophy, a cheque for £1,000 and an inscribed silver medal, was presented to Dr. P. C. Thonemann, head of the ZETA research team. The other members of the group, who share in the award, are Dr. R. Bickerton, Mr. E. P. Butt, Mr. R. Carruthers, Dr. A. N. Dellis, Mr. D. W. Fry, Dr. A. Gibson, Mr. G. N. Harding, Mr. D. J. Lees, Mr. R. W. P. McWhirter, Mr. J. T. D. Mitchell, Mr. R. S. Pease, Dr. S. A. Ramsden, Mr. R. Tayler, Dr. W. B. Thompson and Mr. S. Ward.

In a written answer on April 17 to a question in the House of Commons, the Minister of Education said that projects costing some £2 million have been included in the 1958–59 building programme for additional science accommodation for grammar and technical schools; but he could not say how many grammar schools at present lack adequate science laboratories.

The next meeting of the Biochemical Society will be held in the Department of Biochemistry of the University of Edinburgh on May 17. Further information can be obtained from Dr. P. N. Campbell, Courtauld Institute of Biochemistry, Middlesex Hospital, Mortimer Street, London, W.1.

The Department of Industrial Metallurgy, University of Birmingham, is holding a conference on "The Pressure Welding of Metals" at the University on June 19. Further information can be obtained from the Secretary, Department of Industrial Metallurgy, University of Birmingham, Edgbaston, Birmingham, 15.

The International Commission for Uniform Methods of Sugar Analysis is to hold its twelfth session at the National Bureau of Standards and the Hotel Shoreham, Washington, D.C., during June 2–6. Further information can be obtained from the honorary secretary, Dr. D. Gross, Tate and Lyle Research Laboratories, Keston, Kent.

The annual meeting and summer conference of the Society for Applied Bacteriology will be held in Bristol during July 7–10. Papers will be read on a variety of aspects of applied bacteriology, with the emphasis on the microbiology of fruit and vegetables. Further information can be obtained from the honorary secretary, Mr. G. Sykes, Boots Pure Drug Co., Ltd., Microbiology Division, Standards Department, Nottingham.

SCIENCE AND SOCIETY

A SYMPOSIUM on "Science and Society" was arranged jointly on March 19, at 4.30 p.m., by the Royal Institute of Chemistry (London Section), the Institute of Biology (London Branch) and the London and Home Counties' Branch of the Institute of Physics. The Symposium was held in the William Beveridge Hall, Senate House, University of London. The chairman was Prof. P. M. S. Blackett, and four main speakers dealt with different facets of the subject.

In opening the Symposium, Prof. Blackett said that the problems of the present day reminded him of the turbulent 1930's when younger scientists wondered which way the world was going and what were the implications of their own work. The Second World War and the post-war problems created something of a hiatus, but now we had once again to consider the dangers around us and to determine how science should be used. Nuclear weapons are having an enormous impact on this problem, and the mass feeling to-day is becoming comparable to that of the 1930's. Since science now plays an enormous part in society, we cannot stand aside, but there are no facile solutions. Relatively few scientists are engaged in fundamental research and the efforts of the majority directly affect our standard of living. A steady rise in standards of a few per cent every year in a particular country is not the only important problem in the world as a whole. A major problem is the maldistribution of the benefits due to the advances in technology. The contrasts in different parts of the world are enormous, and the gaps are widening and could prove disastrous. Young scientists should note the world around them. The problems are for all citizens; but scientists have a particular motive because they are responsible for the advances. Scientists should be warned that they are not infinitely wise and should remember that politics is a much more difficult subject than science.

The first speaker was Prof. Lancelot Hogben (University of Birmingham), who spoke on "Science and its Social Functions". He gave a concise history of the relationships between scientists and other sections of the community over the past three centuries. He felt that there was no simple formula for the social use of the scientific worker. The collective efforts of scientists can obviously improve life and relieve social pressures. He preferred to regard science as organized common sense and taking nothing on trust. Science should be above politics, and generally has been. The experience of the 1930's with the economic crisis had shown that although new powers of invention could raise the standard of life, grants for research work—particularly in industry—were the first things to be cut off. To-day we are moving into a planned society, whether we like it or not, and science finds itself closely integrated into the governmental and military machine. We are really faced with a choice between prosperity and destruction. It seems clear that we cannot afford the luxury of disagreement with our potential enemies.

Turning to the future, Prof. Hogben strongly supported Prof. Blackett's appeal at the British Association to provide support and assistance for the under-developed areas. Scientific education could be a bulwark against problems to come, and we must eliminate the disdain of research workers for their teaching responsibilities. One vital need for the future was a reform of human communications.

The next speaker was Prof. A. Haddow (Chester Beatty Research Institute, London), who spoke on the "Social Dangers of Science". He said that the greatest danger to-day was the scientific revolution which was taking place. This revolution could also carry much promise and provide a solution to our problems—material and spiritual. We must particularly watch the danger from the imbalance in the growth of science. The major emphasis now was on the physical sciences which tended to provide gadgets. This may swamp the application of scientific thought to fundamental problems, particularly those of biology and human understanding. There was much apprehension to-day, and he quoted E. M. Forster as saying that the chances of happiness would be improved if we lapse into a period of apathy and uninventiveness. Smuts had advocated a confluence of sciences, arts and religion if man were to survive. One of the greatest assets of science is its objectivity, and a very good example of this was the International Geophysical Year. The question of the responsibilities of science is uppermost in our minds, and there must be a recasting of the traditional outlook if science is to survive. A new sense of responsibility had been expressed by a wide range of people in various countries, and particularly in the leading articles in *Nature*. The idea that scientists' responsibilities are limited is false. They must consider the problems of the age. Responsibilities must be discharged, and these responsibilities include the use of their discoveries. Real progress could come quickly if all scientists could get together for a synthesis of knowledge. Only international understanding will prevent war, and scientists can create such understanding.

At this point Prof. Blackett had to leave the meeting, and the chair was taken by Dr. K. Mellanby, chairman of the London Branch of the Institute of Biology. He introduced the next speaker, Dame Kathleen Lonsdale (University College, London), who spoke on the "Social Place of Scientists". She said that she herself was much concerned with people and their actions. The public in general associates scientists with the frontiers of science and not so much with everyday problems. Knowledge gives scientists very great power, but they seldom want to use it. They are too prepared to hand over power to others who do not use it in the public interest. It is a pity that in some respects many scientists are not quite human. Men want the good things that scientists provide; but they distrust the scientists, whom they regard as powerful but irresponsible and half admire and half fear them. She went on to consider some of the problems that science might tackle; the control of population has been suggested, but who was wise enough to exercise such power?

Passing on to discuss education, Dame Kathleen thought that scientific training was inadequate if decisions have to be made on inadequate information. A broader education was needed for scientists. Few of them required a specialized education, and in any event they should only specialize after a broad education. The Soviet Government regarded the training of scientists as its key problem. Scientists received high pay and there were no problems of grants for research and scientists had plenty of trained assistants. There was, however, a dearth of the latter in under-developed countries.

Turning to the social responsibility of scientists in a democracy, Dame Kathleen said that it was normal for scientists to sit on the fence because they were not sure of the facts. This, however, plays into the hands of bureaucrats and dictators. One cannot renounce personal responsibility in a democracy, and scientists have the duties of citizens. She thought that the preservation of freedom and sanity owes much to the obstinacy of scientists. She mentioned the need to break down barriers between scientists and the lay public, and referred to the good work in this respect which was done by the British Association, the Royal Society, the Royal Institution and the science correspondents of the Press.

The last speaker was Mr. Anthony Smith, science correspondent of the *Daily Telegraph*, who spoke on the "Deployment of Scientific Personnel", or, as he preferred to put it in common-sense language, "Where do scientists go?" His main conclusion was that it does not matter where they go so long as there are scientists. He mentioned the useful careers of men who had read scientific subjects and then entered the world of commerce, law or the arts. In general, the information acquired by an undergraduate at the university was not important, but the training of the mind should fit him for a large variety of occupations. Turning to the question of relations between scientists and the public, he said that he was astounded by the ignorance of a large proportion of newspaper readers on scientific and technical matters. Most of them have considerable influence in the country by virtue of their votes, and it is essential that somehow they should have an understanding of the factors which contribute to the power which their country wields. To-day few people understand the places where power lies, and there is considerable pride in not understanding science. What is worse, there is a longing to have nothing to do with science. People with a scientific education should go into all walks of life, and there might then be a hope of resolving some of the problems he had mentioned.

Dr. C. C. Hall (Royal Institute of Chemistry) took over the chair for question time and brought this most interesting evening to a close.

LONG-DISTANCE RADIO PROPAGATION ABOVE 30 MC./S.

ON January 28 a symposium was held by the Institution of Electrical Engineers in London, at which there were presented more than twenty papers dealing with recent British contributions to the study of long-distance radio-wave propagation at frequencies above 30 Mc./s. This is a field in which important developments have taken place in two respects in the past few years. It has been found first that it is possible, by the use of high radiated powers and directive transmitting and receiving aerials, to communicate over distances of about 1,000–2,000 km. on frequencies exceeding the maximum usable frequency (M.U.F.); and it is known that the transmission occurs via the *E*-region of the ionosphere by a scatter mode of propagation depending upon fluctuations of the electron density in this region. Ionospheric scatter propagation is of particular interest in the frequency band of approximately 25–70 Mc./s.

The second development is concerned with long-distance propagation through the troposphere. It has been known for some thirty years that the transmission of very short waves is not necessarily limited to horizon ranges, as had originally been anticipated. The first examples of beyond-the-horizon propagation of such waves were clearly connected with the existence of abnormal conditions in the troposphere, conditions now generally described by the term super-refraction. More recently, with the use of greater effective radiated powers, it has been found that at all times the field-strength well beyond the horizon is much greater than would have been expected on the basis of standard atmospheric refraction and diffraction around the Earth. The mechanism responsible for this phenomenon is thus not one due to super-refraction in any of its forms, and it is, in fact, ascribed to some kind of scatter propagation which is dependent upon ever-present fluctuations of the refractive index of the lower atmosphere. Long-distance tropospheric propagation, whether due to abnormal refraction or to scattering, is primarily of interest for frequencies in the range of about 30–30,000 Mc./s.; though practical applications of scattering are likely to be restricted to frequencies of 300–5,000 Mc./s., and to distances of up to perhaps 1,000 km.

The first session of the symposium, held in the morning, was devoted to a consideration of research on ionospheric scattering. An introductory paper by F. A. Kitchen and G. Millington gave a survey of recent experiments, with special reference to observations in England on transmissions from Gibraltar at frequencies in the band 37–70 Mc./s. There then followed several papers dealing with special aspects of the studies of the Gibraltar transmissions. D. Williams described a detailed analysis of the structure of scatter signals in which measurements were made of the amplitude distribution, lateral correlation, diversity effects and teleprinter error rates; and it was concluded that a markedly non-Gaussian signal occurs at times. A further analysis of ionospheric scatter signal recordings was presented by G. A. Isted, who discussed diurnal and seasonal effects and the variation of the intensity of the scatter signal with frequency; he also introduced another paper on the subject of interference, both natural and man-made, and stressed its importance in impairing the usefulness of ionospheric scatter communication

circuits in view of the low level of signal which often occurs.

Of the papers concerned with terminal equipment, one, by E. Fitch and R. Ruddleston, dealt with the problem of the correct choice of aerial height, and another, by D. H. Shinn, contained an examination of the kind of radiation patterns required by the aerials for the best use to be made of ionospheric scattering for communication purposes. It has been demonstrated that, if the optimum aerial height, for a given range, is determined on the assumption that the received signal is coherent, then the same height is also correct for the degree of coherence normally encountered with ionospheric scatter signals; furthermore, the effects of the probable variations in the height of the scattering layer and of tropospheric refraction are unimportant for links up to some 1,800 km. in length. As regards the shape of the aerial radiation patterns, there appears to be not much advantage in reducing the horizontal half-power beam-width to less than 30°; and the vertical directivities should be such that the lowest lobes from each terminal overlap well. A paper by P. H. Cutler and D. Williams described a scatter signal analyser capable of being used with rapidly fading signals.

There has been much argument for some time concerning the relative importance of contributions to the residual background signal of scattering due to meteoric ionization and fluctuations of electron density arising from turbulence in the lower *E*-region; and papers by R. W. Meadows and W. C. Bain brought fresh light to bear on this problem. These papers described respectively directional measurements, using the Gibraltar transmissions, on the signal bursts generally considered to be caused by the larger meteors and on the background signal. As a consequence of the scattering process, the radiation arriving at the receiving point is spread over a small range of angles, and it has been found that the mean bearing of the energy distribution of the background signal varies with the time of day in much the same manner as does the direction of arrival of signals from the larger meteors. This provides a clear indication that small meteors contribute considerably to the background signal for much of the time; though, since the mean bearing of this signal relative to the great circle path between the transmitter and the receiver is zero in the middle of the day, a propagation mechanism depending upon the total electron density of the *E*-region and turbulence is certainly not excluded at such times.

Whereas most workers in this field have considered that the short bursts of enhanced signal are due to reflexions from the ionized trails of relatively large meteors, another view has been expressed by G. A. Isted, namely, that many of these bursts are caused by reflexions from transient patches of ionization in the *E*-region produced by upward electrical discharges from thunder clouds. An investigation described by G. S. Kent, in which observations were made on the short bursts of signal received at Cambridge from the television transmitter at Kirk o' Shotts, over a path of 480 km., has now provided strong evidence that the majority at least of the bursts must be attributed to reflexions from meteor trails.

The final paper in the first session, presented by P. J. Brice, was concerned with the amplitude of very-high-frequency signals reflected from the sporadic-*E* layer in north-west Europe. The importance of this matter lies in the fact that scatter communication circuits normally operate with a relatively weak signal, and, if the frequency is appreciably less than 50 Mc./s., there are often times when sporadic-*E* ionization will support transmission by a regularly-reflected propagation mode, thus leading to the possibility of serious interference between common-frequency transmissions—an eventuality which it may not always be possible to prevent even by the use of highly directive aerials. Under such conditions the likelihood of mutual interference is not limited to ionospheric scatter links; other services sharing the same frequency-band, for example, television, may also be involved.

Among the topics most prominent in the discussion at the end of the first session were the nature of the scattering mechanism responsible for the background signal, the variation of the scattered power with frequency, the cause of the larger bursts of signal and the problem of interference. On this last point, in addition to the troubles caused by sporadic-*E* ionization, attention was directed to the difficulties due to the delayed signals which can arise at times when the density of ionization in the *F*2 region is high; and mention was made of round-the-world propagation observed with transmissions from Gibraltar on 37 Mc./s. Some speakers also discussed the practical applications of ionospheric scattering to communication, and the view was expressed that such applications, at any rate in the civil communication field, seem to be few since the transmission capacity is small—limited, in fact, to quite a few telegraph channels—and the quality of telephony is poor. It would appear that the main applications are in the field of military and strategic communications systems.

The afternoon session began with a historical note by G. A. Isted describing pioneer work carried out by G. Marconi during the years 1928–36 on propagation through the troposphere at metre and decimetre wave-lengths. These experiments were made in the Mediterranean area, a region well known to experience widespread and frequent super-refraction; and it seems likely that the long-distance transmissions observed by Marconi were mainly due to this cause, and not to tropospheric scattering as it is now generally understood. The remainder of the papers at this session were concerned with various aspects of the tropospheric propagation of metre waves.

An important feature of long-distance metre-wave propagation is the bearing it has on the problem of interference between common and adjacent channel broadcasting transmitters as used, for example, for television. In this case the interest is in the highest fields, which are reached for only relatively small percentages of the time, and these—at the distances of importance—may be said in general to be due to one or other of the forms of super-refraction, including well-defined elevated reflecting layers. A paper presented by R. A. Rowden, L. F. Tagholm and J. W. Stark gave a survey of investigations carried out over a number of years to provide data from which the minimum spacing of common and adjacent channel very-high-frequency stations may be determined, after the tolerable degree of mutual interference has been defined. Similar work was also described by J. K. S. Jowett: in this paper consideration was given in addition to the effect of path profile on the median field-strength levels and on the

range of fading, and curves of metre-wave field strengths exceeded for various percentages of time between 1 and 99 at distances up to 600 km. were included.

Two other papers were read at the second session. These described investigations aimed at determining the mechanism of propagation responsible for the permanent residual fields at metre wave-lengths far beyond the horizon. B. J. Starkey, W. R. Turner, S. R. Badcoe and G. F. Kitchen have made field-strength measurements in this region on a frequency of 90 Mc./s. in an aircraft flying at a height of some 3,000 m. They maintain that their results—and other experimental results, too—can be explained more readily on the assumption that the mechanism of propagation over such distances is one of reflexions from discrete discontinuity layers in the atmosphere up to the height of the tropopause rather than one of scattering depending upon turbulent fluctuations of refractive index. On the other hand, F. A. Kitchen, E. G. Richards and I. J. Richmond, in discussing results they obtained in experiments on transmissions at 86 and 203 Mc./s. out to ranges of 700 km. over the sea, directed attention to the complexity of metre-wave propagation. They conclude from this work that it is not yet possible to determine whether the residual signal is due entirely to scattering caused by atmospheric turbulence, or to the addition of a small number of coherent signal components of random relative phases, such as would be produced by discrete layers.

In introducing the evening session of the symposium, at which a further six papers on tropospheric propagation were presented, mainly concerned with the long-distance propagation of centimetre waves, J. A. Saxton stressed the point that scattering, in the broadest sense, is fundamental to all propagation through media in which changes of refractive index take place, whether in the form of abrupt discontinuities or as variations in gradient. If a number of scattering centres are involved the signal as observed at a given receiving point may be either coherent at one extreme, or incoherent at the other, depending upon the size of the centres in relation to the wave-length and their spatial configuration. In the strict sense the theory involving the hypothesis of multiple partial reflexions at layer-type irregularities may be regarded as a scatter theory just as much as the theory based on turbulent fluctuations of refractive index, whether isotropic or anisotropic.

B. C. Angell, J. B. L. Foot, W. J. Lucas and G. T. Thompson gave an account of experimental studies of propagation over a path of 280 km. at a frequency of 3,480 Mc./s. The manner in which the characteristics of the signal had varied during a year's observations was described, and an attempt made to associate variations in signal-strength with general trends in the weather. It appeared that the signal tended to be enhanced in foggy weather but depressed during periods of rain. In the presence of fronts across the path the signal was usually higher than average for the time of the year. Some measurements were also made of aerial gain degradation with scatter signals.

The paper presented by G. C. Rider dealt with transmissions on a frequency of 858 Mc./s. over paths of 160 and 320 km. Height-gain and space-diversity investigations were described, and also a comparison of the signals received at four sites of very different aspects within the same locality. This work has shown that the dominant siting requirement for a tropospheric scatter terminal is a low skyline; and it appears that an elevated site offers no advantage other than a greater likelihood of satisfying this condition.

Long-range propagation at wave-lengths of 3 and 10 cm. formed the subject of two papers by W. R. R. Joy, in both cases the transmission paths studied being entirely over sea. An important feature of this work is the discovery that, although the observed signal attenuation rate with distance at 3 cm. wave-length is similar to that expected for a scattered field, the average level of the signal is some 10–15 db. lower than that which would be predicted from current scatter theories based on turbulence. Evidence was also produced that the existence of extensive marked anticyclonic conditions results in relatively low scatter fields. The paper on propagation at 10 cm. wave-length was of particular interest in that it amplified previous accounts of the pioneer work in this field of the late E. C. S. Megaw.

The two remaining papers of the final session were concerned with the theory of tropospheric scatter propagation. M. A. Johnson gave a review of the present state of this theory and its application to experiment: while he made mention of other mechanisms and the circumstances under which they may be operative, he stressed mainly the turbulence hypothesis and proposed a formulation for a comprehensive scattering theory based on this concept. A paper by E. G. Richards was devoted to an estimation of transmission loss in the trans-horizon region, which was based on an expression for the scattering cross-section derived by G. K. Batchelor. It was suggested that experimental results at frequencies of 86, 3,000 and 10,000 Mc./s. indicate that mean-square variations of the refractive index of the atmosphere may be independent of height up to about 650 metres, and that above this they may then vary with the inverse square of the height.

It was not surprising that arguments for and against the turbulence and layer theories figured prominently in the discussions after both of the sessions on tropospheric propagation; and among the points emphasized was the difficulty of distinguishing between the applicability of the two theories purely from the characteristics of the signals received far beyond the horizon. It is obvious that more detailed knowledge of refractive index variations in the troposphere must be obtained by direct observation before a better understanding of the propagation mechanism can be reached. There was considerable discussion also concerning the usefulness of tropospheric scattering for practical communication purposes. On one hand, it was maintained that, for communication within any one country, scatter links are unlikely to be able to compete with conventional radio relay systems in channel-carrying capacity; while other speakers said that scatter circuits were already in use in some countries, though it appeared that they were primarily for military purposes and carried only a relatively small number of communication channels. On the issue of practical applications, several speakers directed attention to the difficulties in communication which may be caused by reflexions from aircraft flying in or near to the aerial beams.

The day's proceedings were summed up by R. L. Smith-Rose, who emphasized that, while experimental investigations of propagation served well to assist the engineer to plan practical communication

systems in the areas where the research had been carried out, it was not always easy to use the same data for engineering purposes in different geographical regions. It is clearly not practicable always to make pilot investigations before every engineering application, and the aim must therefore be to achieve the best fundamental understanding of the propagation phenomena from those experiments which are made, and thus so far as possible to ease the task of extrapolation.

The papers presented at the symposium and the discussion are to be published in a special issue of the *Proceedings of the Institution of Electrical Engineers* (105, B; 1958). J. A. SAXTON

MACHINES AS MODELS IN BIOLOGICAL EXPERIMENTS

IN May 1957 the Laboratory Animals Bureau arranged a symposium on humane technique in the laboratory. In a paper now available separately*, Dr. W. Grey Walter showed how machines could be used as models in biological experiments.

Walter first showed how the classical method of demonstrating physiological laws and principles are derived from those worked out for the physical sciences. The essence of these methods is the isolation of a single variable and the observation of this variable in various experimental conditions. In order to achieve this situation with living creatures, some sort of preparation is required. This involves dissection, mutilation or anæsthesia, often all three, and in this way a whole animal can be transformed into a working model of some particular function. For example, the Sherringtonian approach to reflex action of the spinal cord depended upon decerebration of a complex animal such as a cat and the restriction of attention to one, or occasionally two, reflex circuits. The results obtained in this way form the basis for much thinking about the nervous system, but it is now realized that the general picture of central nervous action derived from these studies of isolation, though admirably clear, lacks perspective and detail when related to animal behaviour.

If it is accepted that animal preparations are essentially models of working hypotheses, it follows that such hypotheses may as legitimately be embodied in machines as in mutilated animals. The use of machines may even present certain advantages: the components of a mechanical system can be accurately enumerated and specified, and the principle of parsimony, so important to fertile thinking, can be adhered to without inconvenience. For example, it is difficult to prove that a spinal cord preparation contains only those components necessary for the reflex action under investigation, but it is quite simple to demonstrate that a reflexive machine contains only essential elements.

The principles to be observed in the construction and use of animal models may be summarized as follows: (1) the system to be modelled should contain more than one variable; (2) the model must contain no redundant components, in order to maintain parsimony; (3) the behaviour of the model should exhibit more features of behaviour than were originally planned or foreseen. Applying these principles, a number of models of animal function and behaviour have been constructed and are in frequent use both for the design of fresh experiments and for teaching purposes. These are:

(1) NERISSA—A Nerve Excitation, Inhibition and Synaptic Analogue. This demonstrates particularly the relationship between the various parameters of nervous action such as finite propagation-rate, excitation threshold, all-or-none conduction, strength-duration curves of excitability, refractory periods, Wedensky inhibition, synaptic facilitation and inhibition, inhibitory escape and rebound, transmission or information by pulse-interval modulation, and anomalies of 'inhibition of inhibition' and 'inhibition of inhibition of inhibition' during rhythmic as opposed to sustained stimulation.

(2) IRMA—Innate Releaser Mechanism Analogue, demonstrating the exclusive action of an excitatory state maintained by a cascade of neuronic elements and the effect upon this condition of variations in excitatory level.

(3) ELMER—Electro-Mechanical Robot, containing two elements equivalent to synaptic junctions, with two receptors and two effectors, to demonstrate the complexity of behaviour arising from the interaction of two reflex circuits coupled to a complex environment. The behaviour patterns observable include goal seeking, obstacle avoidance, discrimination between immediate and remote goals, choice between two equivalent goals, tendency to seek optima rather than maxima and elements of self- and social-classification.

(4) CORA—A Conditioned Reflex Analogue, demonstrating the action of selective and storage mechanisms in the establishment of a contingency association between signals on a basis of statistical significance.

Such models provide both student and experimenter with an opportunity to classify observations of real animals and to design crucial experiments.

* Laboratory Animals Bureau. Collected Papers, Vol. 6, 1957. Pp. 81. (London: Laboratory Animals Bureau, M.R.C. Laboratories, 1957.) 10s.

EDIBLE LIZARDS

ALLAN R. HOLMBERG, of the Department of Sociology and Anthropology of Cornell University, has described how natives of the north coast of Peru capture small lizards called cañanes partly for their nutritive but especially for their curative and aphrodisiacal properties*.

The lizards, *Dicrodon hoombergi*, are found in the Chao Valley and dig their holes in the desert sand around clusters of the guarango tree (*Prosopis juliflora*)—called algarrobo in Viru—the fruits of which constitute their sole means of subsistence. They are not gregarious, but hundreds of pairs of them make their homes around nourishing stands of algarrobo. The full-grown males are bluish in

* Fieldiana Anthropology, 36, No. 9. (Chicago Natural History Museum, 1957.) 75 cents.

colour and attain an over-all length of about 20 inches; the females, more brownish in colour, seldom grow to three-fourths of this size. Both males and females have speckled backs, and most of their length consists of tail. Viruñeros claim that cañanes are ovoviviparous.

Cañanes spend most of their lives underground. Here they hibernate during the winter (April to November) and here they raise their young. Only when the summer months appear do heat and hunger drive them from their holes, and then only for a few hours on days when the sun is shining. When the weather is warm, they raise their heads out of their holes at about 9 o'clock in the morning, and begin to feed on the green fruits of the algarrobo. Since few tender ones are to be found on the ground, the cañanes usually climb the spiny trees. In this way they not only reach the more luscious pods, but also avoid attacks by larger lizards locally known as iguanas, and by foxes, vultures and hawks, which sometimes kill them when they are caught in the open. After eating for a few hours, the cañanes return to their holes, sometimes taking with them pods which are stored for winter.

Cañanes are usually caught in traps. These consist of long, low fences made from small, roughly rectangular staves of maguey—about 15 inches long, $\frac{1}{4}$ inch wide, and $\frac{1}{4}$ inch thick—twined in a series with cotton string. When rolled up, a trap has the appearance of a drum or tambor, as it is called in Viru.

At the site, the traps are rolled out flat on the sand at about a yard from the low-lying algarrobo branches containing fruit. Then they are gradually set up—inclined slightly inward—and banked on the bottom (both inside and out) with sand. A cañan trap, when set up, thus presents the appearance of a miniature picket fence, inclining slightly inward and enclosing a large open space within which lie holes of cañanes and outside of which lie clusters of algarrobo.

Meanwhile, the cañanes have come out of their holes to eat. On their way, they encounter the barrier of the trap. Instead of returning to their holes, they continue to search for some avenue of escape to the algarrobo fruits, but everywhere they go they encounter the trap or its curled ends—a difficulty which their lack of intelligence does not permit them to overcome.

The hunter then gathers up his cañanes, breaks their front legs and backs—they are thus paralysed but remain alive—and places them in a pair of woven saddle bags.

In Viru there still persists the flavour of the fiesta in the cañan hunt. Until recent times, no Viruñero thought of dedicating all his time to this pursuit or of making a living from it, but most of the hunters possessed traps which they occasionally set during the season to enjoy a day of fiesta. To-day, a few skilled hunters have dedicated themselves to the hunt for commercial reasons, since there is an excellent market for cañanes both in the valley and in the neighbouring cities, where they sold for as much as four soles a dozen in 1948.

After being collected from the trap, the paralysed cañanes are laid out in a row near the ashes of a dying fire. They are thrown into the embers and are scorched to death.

Cañanes subjected to the scorching and cooking treatment may be eaten as they are, may be prepared in various ways, or may be stored for as long as a year. They may be eaten raw. Commonly, however, they are prepared in seviches, soups, stews, or omelettes.

MUSCLE-RELAXING FACTORS

By J. R. BENDALL

Low Temperature Station for Research in Biochemistry and Biophysics, University of Cambridge, and Department of Scientific and Industrial Research

BRIGGS and Portzehl[1] and Portzehl[2] have recently published detailed observations on the nature of the muscle-relaxing factor discovered by Marsh[3] which show that :

(*a*) The factor is not identical with phosphokinases such as creatine phosphokinase (C.P. kinase) or phosphopyruvate-kinase (P.P.-kinase), as suggested by Goodall and Szent-Györgyi[4], Lorand[5] and Moos and Lorand[6], nor, by implication, with myokinase (ADP-kinase) as suggested by Bendall[7]. In other words, its mode of action is not through the maintenance of the adenosine triphosphate (ATP) level against the inroads made by the myofibrillar adenosine triphosphatase (ATP-ase), which can be summarized by the equation :

$$\text{ATP} \xrightarrow{\text{ATP-ase}} \text{ADP} + \text{P}_i$$

$$\text{ADP} + \left\{\begin{array}{l}\text{ADP-kinase}\\ \text{C.P.-kinase}\\ \text{P.P.-kinase}\end{array}\right. \longrightarrow \text{ATP}$$

Nevertheless, these enzymes can serve to carry adenosine triphosphate to the centre of thick bundles of fibres where otherwise it could not penetrate, and it is in this ability that their apparent factor activity resides. These other 'relaxing' systems are without effect, however, in exhaustively washed or very old fibre bundles[7], nor will they inhibit the adenosine triphosphatase activity of washed myofibrils[8,9], and it is obvious, therefore, that some other substance is responsible for the inhibition and relaxing effect of adenosine triphosphatase which can be obtained by addition of crude muscle-extracts to such washed systems.

(*b*) The activity of the true relaxing-factor, dialysed free of phosphate esters and other soluble metabolites, is dependent upon *p*H, and, when present in trace amounts, is more active at low *p*H ($\sim$6·2) than at high ($\sim$7·2). This explains why the relaxing effects which Goodall and Szent-Györgyi[4] attributed to creatine phosphokinase were only observed at low *p*H values.

(*c*) Factor activity mainly resides in the particulate material of the muscle-extracts, which can be centrifuged down between 20,000 and 80,000 g[10]. This fraction probably consists of the smaller granules of Chappell and Perry[11] and makes up a large part of the active factor preparation of Kumagai, Ebashi and Takeda, called by these workers fraction *A*.

(*d*) The factor is very sensitive to calcium ions, which are liberated from their bound state on the myofibril during its preparation. The presence of oxalate overcomes this difficulty[12].

Of all the characteristic effects of the factor, however, its inhibition of synæresis of fibres in the presence of adenosine triphosphate is perhaps the most sensitive, and it was here that its identity with myokinase in particular was first questioned (ref. 3 and personal communication, 1956). This, indeed, was a most serious criticism of the 'myokinase' hypothesis.

I now wish to report experiments on synæresis and adenosine triphosphatase activity which essentially confirm the findings of Briggs and Portzehl[1]. The factor was prepared in this work by homogenizing the muscle in 3 vol. of buffer (*p*H 7·2), consisting of 80 m*M* potassium chloride/20 m*M* imidazole/5 m*M* potassium oxalate, centrifuging at 3,000 r.p.m. to remove myofibrils and then fractionating the supernatant as follows: (1) Centrifuging at 18,000 *g* for 10 min.; this brings down the larger granules which are inactive as factor. (2) Re-centrifuging the supernatant from (1) at 80,000 *g* for 30 min.; this brings down granules which possess high factor activity. These granules were then re-suspended in buffer and re-centrifuged at 80,000 *g*, again for 30 min. Finally, the washed granules were made up with buffer, in the proportion of 1 ml. buffer to the equivalent of 1 gm. of original muscle. All operations were carried out at 0° C.

The following results were obtained:

(1) *Inhibition of adenosine triphosphatase activity.* Adenosine triphosphate was added to a washed preparation of 1 day-old myofibrils[9] in the presence of: (*a*) buffer only; (*b*) an active myokinase preparation (cf. Bendall[7]); (*c*) 'high-speed' granules; (*d*) 'high-speed' granules + 0·2 m*M* calcium chloride. The results are shown in the form of time-curves in Fig. 1, where we see that myokinase merely accelerates splitting, whereas the granules slow down the initial rate of splitting, and later inhibit it almost completely. Addition of 0·2 m*M* calcium chloride, however, immediately restores the splitting-rate to its control-level or above. It should be noted that the adenosine triphosphatase activity of the granules alone did not contribute more than 2μ AP_i/min./gm. to the overall rate.

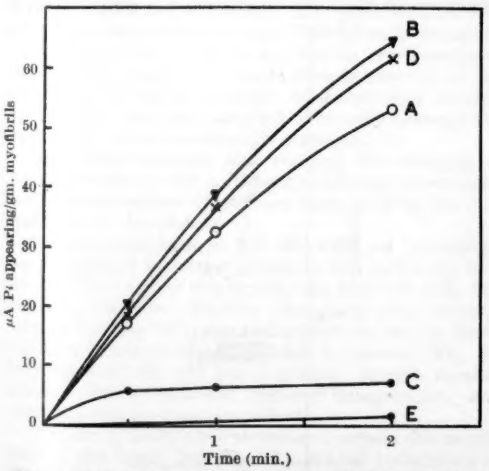

Fig. 1. Effect of various preparations on adenosine triphosphate activity of myofibrils. Buffer as in text, but 4 m*M* magnesium chloride added. Adenosine triphosphate, 4 m*M* throughout. Fibrils, 0·6 gm. in final vol. of 18 ml. Granules added ≡ ~ 1·5 gm. muscle. Splitting of adenosine triphosphate by fibrils was measured in the presence of: (*A*) buffer alone; (*B*) myokinase; (*C*) granules; (*D*) granules + 0·2 m*M* calcium chloride. Splitting by granules alone, no fibrils, is shown in (*E*)

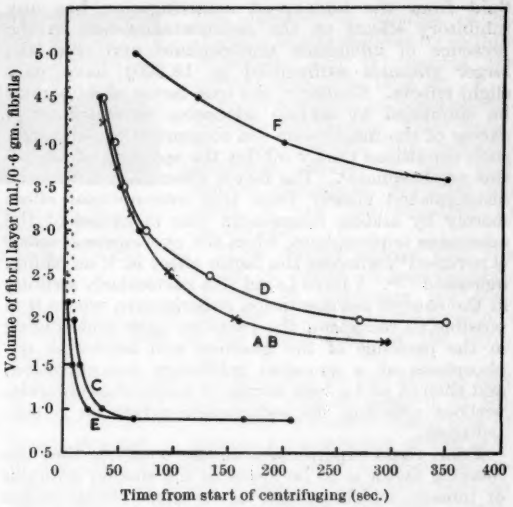

Fig. 2. Effect of granules on sedimentation of myofibrils at 3,000 *g*. Conditions as in Fig. 1, but 0·6 gm. fibrils in 6 ml. to which granules added ≡ ~ 1·5 gm. muscle. Fibrils centrifuged in the presence of: (*A*) buffer alone; (*B*) granules alone; (*C*) adenosine triphosphate alone; (*D*) adenosine triphosphate + granules; (*E*) adenosine triphosphate + granules + 0·2 m*M* calcium chloride; (*F*) adenosine triphosphate + granules, but fibrils contained some intrinsic factor

(2) *Synæresis of myofibrils.* For this purpose 0·6 gm. aliquots of washed fibrils in the presence of 6 ml. buffer were placed in 10 ml. graduated centrifuge tubes, and spun at 3,000 *g*. The volume of the fibril layer during spinning was observed by the optical method of Marsh[3]. Fig. 2 illustrates the rate of sedimentation of this layer, from the first moment at which it could be observed (vol., 4·5–5·0 ml.) until sedimentation was virtually complete. Conditions were the same as in the adenosine triphosphatase tests. The fibrils were spun in the presence of: (*a*) buffer alone; (*b*) buffer and granules; (*c*) adenosine triphosphate alone; (*d*) adenosine triphosphate + granules; (*e*) adenosine triphosphate + granules + 0·2 m*M* calcium chloride; (*f*) adenosine triphosphate + granules, but fibrils contained intrinsic factor.

It is clear from the results that the 'high-speed' granules in the presence of adenosine triphosphate have a very large inhibitory effect on the fibril-volume decrease, and in fact it is doubtful whether synæresis proper ever occurs in their presence. This is even more strikingly brought out by the increased inhibition which occurs when granules are added to fibrils which still contain some intrinsic factor (Fig. 2,*F*). Such fibrils alone would show a reduced rate of synæresis in adenosine triphosphate about equivalent to the curve for buffer alone, that is, there are considerable amounts of factor still present. On the other hand, the factor effect is completely reversed by the addition of 0·2 m*M* calcium chloride, in the presence of which the sedimentation occurs so rapidly that it is impossible to measure it accurately.

Although not shown in the figure, it must be stressed that neither myokinase nor the supernatant

fluid from the high-speed centrifugation has any inhibitory effects on the sedimentation-rate in the presence of adenosine triphosphate and that the larger granules sedimented at 18,000*g* have only slight effects. Similarly, the true factor effect cannot be simulated by adding adenosine triphosphate in excess of the magnesium ion concentration, although such conditions partly inhibit the splitting of adenosine triphosphate[8]. The factor effect can, in fact, be distinguished clearly from this over-optimal effect merely by adding magnesium ions in excess of the adenosine triphosphate, when the over-optimal effect is reversed[13], whereas the factor effect is, if anything, increased[10,14]. I have found this particularly striking in the case of sedimentation experiments, where it is possible to resuspend the particles after centrifuging in the presence of the granules and adenosine triphosphate at a so-called inhibitory concentration, and then to add a vast excess of magnesium chloride, without affecting the sedimentation-rate on re-centrifuging.

From these experiments we can conclude that the relaxing factor is to be found in the smaller granules of muscle, which possess all its most characteristic features, and that its apparent identity with myokinase or other similar kinases is attributable solely to the difficulty of washing it out completely from thick bundles of fibres. For similar reasons, it is equally difficult to put it back again into the bundles, probably because the particles of which it consists become clumped during preparation. This difficulty is not encountered, however, with single fibres[1] or with fibrils, which show relaxation and swelling, respectively, in its presence.

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EFFECT OF ACETYLCHOLINESTERASE ON THE SURVIVING FROG HEART

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Trichloroacetic acid extracts of frog hearts show, in the ultra-violet range of 210–280 mμ, one absorption maximum only at 255–260 mμ. Their perfusates with Ringer's solution in 19 out of 68 cases showed another small maximum at 275 mμ (Fig. 1). The former absorption is by the purine derivatives of the nucleic acids. The latter is, at least partially, due to a cholinesterase, for the following reasons: (1) the ultra-violet absorption spectra of three preparations of red blood cell true acetylcholinesterase and one of *Electrophorus electricus* acetylcholinesterase, in great dilutions, were similar to the absorption of frog heart perfusates; (2) out of the 19 frog heart perfusates which absorbed in this band seven were found to split acetylcholine.

It has long been known that saline perfusates of frog hearts often have a positive inotropic effect on the heart enfeebled by prolonged, repeated washings. Out of 37 of our frog hearts perfusates, 21 have had a positive inotropic action. A. J. Clark[1] suggested that washed-off lipids were the active principle. Recently, Hajdu *et al.* isolated palmito-lecithin from blood plasma and other mammalian tissues, demonstrated its strong digitalis-like activity and suggested that it may be the active principle[2].

The seven frog heart perfusates which split acetylcholine and had an absorption maximum at 275 mμ were among those which have had a positive inotropic effect.

We conclude from these observations that cholinesterase appears sometimes in the saline perfusates of surviving frog hearts and that this cholinesterase is one of the positive inotropic substances of some frog heart perfusates.

Spadolini and Giachetti[3] in 1953 reported that extracts of guinea pig brain containing unassayed amounts of acetylcholinesterase have a strong positive inotropic action.

It is also deemed likely that in some of the saline or water perfusates or extracts of hearts and organs with a cardiotropic action, described by previous authors, cholinesterases might be the bearers of this action[4–9].

It is suggested, further, that one of the physiological functions of blood cholinesterase is a contribution to

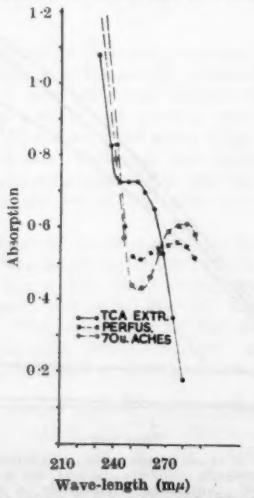

Fig. 1. Absorption spectra in the ultra-violet band of 10 per cent trichloroacetic acid extracts of frog hearts ●——●; of Ringer perfusates of frog hearts × - - - ×; 70 units red blood cell true acetylcholinesterase O - - - O. All substances in frog heart Ringer's solution pH 7·6, 24° C.

Fig. 2. Record of the isotonic beats of a surviving frog heart suspended on a Straub cannula. The heart was made very hypodynamic by numerous washings with acetylcholine and sodium acetate and Ringer for more than 5 hr. At 1, 3, 5, Ringer's solution off. At 2 and 4, Ringer added. At 6, N.B.C.. acetylcholinesterase 70 units + 2·8 m*M* sodium phosphate added. At 7, this perfusate off

the maintenance of the contractile strength of the heart.

A study of the cardiotropic activity of the four acetylcholinesterase preparations at our disposal gave the following results: out of 28 feeble, spring frog hearts 23 responded with an increased amplitude of the beats to an addition of one or other of the four acetylcholinesterase preparations (Fig. 2). Strong hearts of freshly caught summer frogs either did not respond with an increased amplitude or with an increase up to a third of the original beat only. The lowest effective concentration tested so far was 0·7 units per ml. Ringer's solution. The amplitude of the beats increased by acetylcholinesterase may remain large for several consecutive washings with acetylcholinesterase-free Ringer or it may even increase during these washings. Spadolini and Giachetti described similar effects produced by their guinea pig brain extracts.

The positive inotropic substance is heat labile because incubation at 56° C. for a few minutes not only destroys it but turns the positive inotropic action to negative. It is also linked to a free esteroclastic group because the presence of 1×10^{-4} eserine inhibits the development of a positive inotropic action, though smaller eserine doses ($0{\cdot}5 \times 10^{-5}$) do not diminish the increased amplitude in hearts responding well. 10^{-6} and 10^{-5} atropine prevented the negative inotropic effects of 10^{-6} and 10^{-5} acetylcholine respectively but not the positive inotropic effect of acetylcholinesterase. The effect is primarily on the amplitude of the beats, that is, work performance of the heart; for this a minute activity of the pacemaker is indispensable. The rate and rhythm of the heart are only affected indirectly through the restoration of the contractile strength.

Acetylcholinesterase also restores the strength of hearts weakened by a Ringer's solution containing low concentrations of calcium ions or high concentrations of phosphates.

Sodium phosphate in 2·8–280 m*M* concentrations has a negative inotropic action on the surviving frog heart. The higher concentrations stop (or kill) the heart in diastole. Sodium phosphate acts through calcium binding[10–12]. Restoring calcium ions by direct addition increases the amplitude to normal (Fig. 3). Reduction of the *p*H has a similar, though smaller effect. Other bivalent cations (magnesium and barium) have no restoring effect.

70 units of acetylcholinesterase increase the amplitude of the beats depressed by graded reductions of the calcium content of the perfusing Ringer's solution, but it has no effect in a calcium-free Ringer's solution. As the calcium content is raised the increase in amplitude of contractions caused by acetylcholinesterase becomes inversely proportional to the calcium content. Acetylcholinesterase (350 units/ml.), like calcium, is capable of restarting hearts stopped by sodium phosphate and it restores the normal amplitude (Fig. 3).

Fresh solutions of acetylcholinesterase containing 7,000 units/ml. can prevent the negative inotropic effects of 280 m*M* sodium phosphate, provided the heart is not too sensitive to phosphate.

These results suggest that the mode of action of acetylcholinesterase in increasing the contractile strength of the heart is linked to the functions of calcium ions in the metabolism of the myocardium.

Determinations of absorbance at 255–260 mμ and of acetylcholine equivalent (rectus assay[14]) of the trichloroacetic acid extracts of normal hearts and of hearts stopped in diastole by a mixture of 280 m*M* of sodium phosphate, 7,000 units of acetylcholinesterase and 33 mgm. of gelatin threw some light on the mode of action of calcium ions and acetylcholinesterase.

The absorbance of the trichloroacetic acid extracts (diluted 1 : 100 per wet heart weight) of the hearts stopped in diastole dropped to 0·53 ($\delta\bar{x} = 0{\cdot}18$, $n = 10$) from the normal 0·72 ($\delta\bar{x} = 0{\cdot}23$, $n = 10$). As the positive inotropic purine derivatives absorb at this wave-length it follows that their concentration diminishes both in the washed hypodynamic hearts and in the hearts stopped in diastole by a diminished calcium ion concentration due to their binding by sodium phosphate. (It was shown recently that the

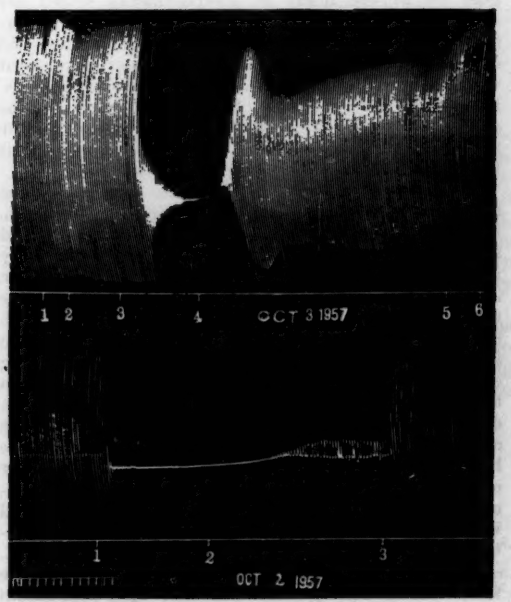

Fig. 3. Records as in Fig. 2. Top: Effect of 350 units acetylcholinesterase on the frog heart stopped by 7 m*M* of sodium phosphate. At 1, Ringer's solution off. At 2, Ringer on. At 3, 7 m*M* sodium phosphate. At 4, 350 units acetylcholinesterase. At 5, perfusate off. At 6, Ringer's solution on. Bottom: Effect of calcium chloride on the frog heart stopped by 2·8 m*M* sodium phosphate at 1. At 2, 0·28 m*M* calcium chloride. At 3, 2·8 m*M* calcium chloride

adenosine nucleotide levels were reduced to about half the normal in dog hearts stopped in diastole by anoxia[15].)

Strong summer hearts show a spontaneous gradual recovery in the presence of a mixture of 280 m*M* phosphate and 7,000 units of acetylcholinesterase. A direct correlation ($0{\cdot}01 > P > 0{\cdot}005$) was found between the absorbance of the trichloroacetic acid extracts at 255 mμ and the time which elapsed between the stoppage of the heart and the extraction of the heart. Acetylcholinesterase then exercises its positive inotropic action by accelerating the processes which restore the essential purine derivatives to the heart.

As these purine derivatives, absorbing at 255–260 mμ, appear in the perfusing Ringer their concentration in the washed and stopped heart diminishes because they are split off from the contractile proteins to which they are bound[16,17] and diffuse into the perfusate. Acetylcholinesterase and calcium ions apparently act on those enzymic processes which pass back the purine derivatives into the cell and which link them to the contractile proteins.

The acetylcholine equivalent (rectus assay of the trichloroacetic acid extracts) of hearts stopped by a mixture of 280 m*M* sodium phosphate and 7,000 units of acetylcholinesterase was 3·92 μgm./gm.; that of the normal hearts, and hearts whose beats were increased by acetylcholinesterase, was 2·00 μgm./gm. The increase in the acetylcholine equivalent of the stopped hearts is thus greater by 92 per cent ($0{\cdot}001 > P > 0{\cdot}0001$).

It is noteworthy that the hearts perfused with 7,000 units of acetylcholinesterase contained not less but more acetylcholine than the hearts perfused with Ringer's solution. Clearly acetylcholine synthesis goes on in the heart in compartments which are not reached by the acetylcholinesterase in the perfusate, and in which the acetylcholine synthesized is held indiffusible[18]. These conclusions are consistent with Hebb and Smallman's finding that in rabbits' brains the mitochondrial fraction contains choline acetylase[19]. The acetylcholinesterase added to the perfusing Ringer's solution, on the other hand, is bound to the surface of the myocardial cell.

As regards the mechanism of the increase in the acetylcholine content of the phosphate-stopped hearts, it may be recalled that Feldberg and Mann[20] showed that calcium ions from 0·0018 *M* upwards strongly inhibit acetylcholine synthesis, whether potassium is present or not. It may be assumed that the 0·00108 *M* calcium ion present in Ringer's solution normally inhibits choline acetylation. This calcium is bound by the added sodium phosphate, thus freeing choline acetylation from calcium ion inhibition. On the other hand, splitting of acetylcholine by acetylcholinesterase depends on the presence of calcium ions[21]. Thus the ionic condition of calcium in the heart treated with sodium phosphate is favourable for choline acetylation; it is unfavourable for acetylcholine hydrolysis. It follows that in hearts treated with sodium phosphate, an increased acetylcholine content is expected, and that is what was actually found.

While there is a direct correlation between the time which elapses between addition of sodium phosphate and extraction of the heart, and ultra-violet absorption at 255–260 mμ of the trichloroacetic acid extracts, there was no correlation between this time and the extractable acetylcholine equivalent. Although phosphate poisoning diminishes ultra-violet absorption and increases acetylcholine content, the inverse correlation between these two parameters is barely significant ($0{\cdot}1 > P > 0{\cdot}05$), a circumstance indicating that restoration of ultra-violet absorption and diminution of acetylcholine content to normal are two separate processes with some stages linked.

Besides calcium ions and acetylcholinesterase, fructose 1-, 6-diphosphate (0·1 m*M*) was also able to restore to the heart treated with sodium phosphate its ability to beat at a normal amplitude.

Glycogen, glucose, glucose-6-phosphate and β-glycerophosphate had small or no effects. 0·16 m*M* adenosine triphosphate, positively inotropic in normal Ringer's solution in the heart beating normally, restored the depressed amplitude of hearts beating in the presence of 2·8 m*M* trisodium phosphate and 70 units of acetylcholinesterase. 0·38 m*M* adenosine, on the other hand, caused arrythmia and diastolic stoppage in these hearts, though in normal Ringer's solution in normal hearts it often had a positive inotropic effect.

Acetylcholine, choline and sodium acetate were also ineffective. Adrenaline and noradrenaline, on the other hand, exerted positive inotropic effects.

Palmito-lecithin (1·35 m*M*) also could exert its digitalis-like effect on hearts depressed by sodium phosphate.

The cholinesterase on the surface of the myocardium then has an important function in the maintenance of the strength of the myocardial contractions. It performs this function in co-operation with calcium ions by regulating the metabolism of essential purines. Changes in the calcium, phosphate and hydrogen ion concentration also modify other enzymic processes. An example of this is the extractable acetylcholine content of the heart, which increases when the calcium ion content is diminished by sodium phosphate.

A detailed account of this work will be published elsewhere.

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LETTERS TO THE EDITORS

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Determination of the Absolute Configuration of α-Quartz

For the determination of the configuration, including handedness (that is, the absolute configuration), of non-centrosymmetrical crystals, use must be made of anomalous scattering[1]. In one set of applications the intensity difference between hkl and $\overline{hkl}$ reflexions is employed only in a qualitative way for a few reflexions, the structure except for handedness being known[2]. In others, methods have been devised for a fully direct Fourier synthesis, utilizing the anomalous effect of all reflexions in a qualitative[3] or quantitative[4] way. It was realized that applications of anomalous diffraction were not limited to crystals containing atoms with absorption edges very close to the frequency of the X-rays used[3].

The present investigation, the determination of the absolute configuration of α-quartz, is of the former type. It has been undertaken to reveal the absolute configuration of this historical crystal; and in addition, to investigate whether the accuracy of intensity measurements could be improved to such a degree that anomalous diffraction could be utilized with these very light atoms, and consequently with X-ray frequencies very far from the absorption edge.

In the case of quartz, the determination of the absolute configuration means establishing whether the space group of a given crystal is $P3_112$ or $P3_212$. This can be decided by the comparison of calculated and measured intensities for a small number of reflexions. Intensities were calculated using the co-ordinates of Brill *et al.*[5] adapted to the space group $P3_112$. The measured intensities were obtained from a part of an α-quartz crystal turned off cylindrically, irradiated with chromium-$K\alpha$ X-rays (development of the faces, Fig. 1, as well as rotatory power proved the quartz crystal to be lævorotatory). The intensity of a given reflexion appeared to vary considerably with the part of the crystal irradiated, due to the degree of ideality of the natural quartz crystal varying from spot to spot. So averaging was required of repeated intensity measurements of the same reflexion from different parts of the crystal.

Fig. 1

The pairs of reflexions $hkil$ and $\overline{hkil}$ measured can be divided into three groups. First, the pairs of reflexions with $l = 1$ and $k = \overline{h}$, which are structurally different (Table 1). Their intensities enable us to determine the directions of the crystallographic axes in the cylindrically shaped crystal sample. The large discrepancy between measured and calculated ΔI (per cent) for 1 $\bar{1}$ 0 is not surprising, for it is a strong reflexion likely to be affected by extinction.

Table 1. Reflexions $h\ \overline{h}\ 0\ 1$

hki	Measured I_{hkil}	Measured $I_{\overline{hkil}}$	Measured ΔI*	Measured ΔI (per cent)*	Calc. ΔI (per cent)
1 $\bar{1}$ 0 and cyclic	80·0	131·0	$\overline{51{\cdot}0}$	$\overline{48}$	$\overline{83}$
2 $\bar{2}$ 0 and cyclic	22·8	11·5	11·3	66	59
3 $\bar{3}$ 0 and cyclic	0·0	116·0	$\overline{116{\cdot}0}$	$\overline{200}$	$\overline{198}$

* In this table and in Tables 2 and 3 $\Delta I = I_{hkil} - I_{\overline{hkil}}$ and ΔI (per cent) $= 100 \times \dfrac{\Delta I}{\frac{1}{2}(I_{hkil} + I_{\overline{hkil}})}$

In the second group, the reflexions with $l = 0$ and $k = \overline{h}$ (Table 2), the reflexions $hkil$ and $\overline{hkil}$ are equivalent. Their agreement is a test of the reliability of the intensities.

Table 2. Reflexions $h\ \overline{h}\ 0\ 0$

hki	Measured I_{hkil}	Measured $I_{\overline{hkil}}$	Measured ΔI	Measured ΔI (per cent)
1 $\bar{1}$ 0 and cyclic	53·6	53·8	$\overline{0{\cdot}2}$	$\overline{0{\cdot}4}$
2 $\bar{2}$ 0 and cyclic	51·4	51·9	$\overline{0{\cdot}5}$	$\overline{1{\cdot}0}$
3 $\bar{3}$ 0 and cyclic	18·4	18·2	0·2	1·0

The third group consists of pairs with $l = 0$ or 1 and $i = k$ (Table 3). In these pairs, where $\overline{hkil}$ is equivalent to the anti-reflexion of $hkil$, the intensity difference is caused by anomalous scattering and therefore determines the handedness of the configuration.

Table 3. Reflexions $h\ k\ k\ l$

hki	l	Measured I_{hkil}	Measured $I_{\overline{hkil}}$	Measured ΔI	Measured ΔI (per cent)	Calc. ΔI (per cent)
2 $\bar{1}$ $\bar{1}$ and cyclic	0	51·1	59·8	$\overline{8{\cdot}7}$	$\overline{16}$	$\overline{16{\cdot}0}$
2 $\bar{1}$ $\bar{1}$ and cyclic	1	12·4	19·1	$\overline{6{\cdot}7}$	$\overline{42}$	$\overline{43{\cdot}0}$
4 $\bar{2}$ $\bar{2}$ and cyclic	1	51·8	47·8	4·0	7	6·4

From the discussion on the intensities the choice of space group is seen to be the right one. The lævorotatory α-quartz therefore belongs to the space group $P3_112$, in agreement to the prediction of Wooster[6]. The structure has right-handed spirals, which the light seems to follow in its rotation[6]. (The term lævorotatory refers to the observer to whom the light is travelling.) A further theoretical study of the rotatory power of quartz is intended.

I thank Prof. J. M. Bijvoet for his continuous interest in this investigation, Prof. W. Nieuwenkamp for supplying the quartz crystals and determining the optical rotatory power and Dr. A. F. Peerdeman for advice and for checking the results.

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Importance of the Faraday to Elemental Constants and Electricity Standards

Recent values of the ratio e/m as measured physically by deflexion in a magnetic field and as measured by electrochemical deposition or erosion permit combination in such a way that errors arising from uncertainties in the acceleration, g, due to gravity may be eliminated[1]. Work now in progress at the National Bureau of Standards on the gyromagnetic ratio (*loc. cit.*, pp. 168–69) will permit an even more fortunate elimination.

In this new work the gyromagnetic ratio of the proton, γ, is being measured in a precision solenoid for which the coil constant can be calculated to an accuracy of a few parts in 10^6, giving:

$$\gamma = \omega_s/kI \qquad (1)$$

where ω_s is the precession frequency, k the constant for the solenoid and I the current in amperes. If the value of γ so determined is used for measuring a magnetic field in which e/m is to be determined by observing the cyclotron frequency of the proton, say, then we can express e/m in coulombs per gm. for a singly-charged particle of unit atomic weight by:

$$(e/m)_p = \omega_p \gamma M_p/\omega_B = \omega_p\omega_s M_p/\omega_B kI \qquad (2)$$

where ω_p is the cyclotron frequency of the particle, ω_B the precession frequency in the same field, and M_p the mass of the particle in atomic units.

Determination of the Faraday by electrochemical deposition or erosion gives:

$$(e/m)_c = M_c It/m_c \qquad (3)$$

in which M_c is the mass of the atom in atomic units of the substance involved in the process, I the current in amperes, t the time it flows, and m_c the mass deposited or eroded. In this case $(e/m)_c$ is expressed in the same units as $(e/m)_p$.

Multiplying equations (2) and (3) yields

$$e/m = \sqrt{(e/m)_p\,(e/m)_c} = \sqrt{\omega_p\omega_s M_p M_c t/\omega_B k m_c} \qquad (4)$$

Thus, the dependence of e/m on the electricity standards is eliminated. All the quantities on the right-hand side of equation (4) can be measured with considerable accuracy. Since their major errors are uncorrelated, the error in e/m is obtained by half of each individual error added in quadrature. The greatest errors are associated with ω_p, due to perturbing forces on the particles, with m_c, due to chemical impurities, and with M_c, if the substance used contains more than one isotope. There seem to be means available now whereby the uncertainties in these quantities may be reduced considerably with respect to what has been possible in the past, giving considerable improvement in accuracy of e/m.

The interesting aspect of this elimination is that with the more precisely known constants such as R_∞ and α, the Rydberg and fine-structure constants, M_e the mass of the electron in atomic units, and c the speed of light, the elemental constants e, h, m, etc., can be freed of uncertainties due to the electric standards and the acceleration of gravity. In adjustments to obtain the best values of these constants, the uncertainties in the electric standards and gravity are usually neglected, though not overlooked, in assessing the errors of the constants.

Conversely, dividing equation 3 by equation 2 yields:

$$I = \sqrt{m_c\omega_p\omega_s M_p/M_c t\omega_B k} \qquad (5)$$

which gives the value of the current used in the experiments in absolute electric units, subject only to the errors of the quantities under the radical sign. This affords a determination of the accuracy of the electric standards used, quite independent of the errors involved in their experimental determination. Actually, the solenoid being used for the experiment for the determination of γ is the same as that used for determining the ampere by the Pellat balance method (*loc. cit.*, p. 153). However, the constant of the solenoid is so well known that its contribution to the error of that experiment is negligible.

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Possible Existence of Anti-Matter in Bulk

Of the many craters on the Earth known to have been produced by fallen meteors, a few have left no signs of the meteor which caused them, apart from the huge holes created in the Earth's crust. Large meteorite fragments have been found in or near most craters. A possible explanation of the lack of meteorite fragments in the other cases is that the meteors concerned were of contraterrene constituency (anti-matter). In this case no traces of the meteors would remain, due to the annihilation process. One of these events, from which no fragments appear to have survived, has occurred in recent years. In 1908 a meteor[1], apparently of great size, was seen passing over western Russia; a few minutes later it crashed in the Siberian wastes with an explosion, effects of which were felt for hundreds of miles around, and seismographs thousands of miles away registered its impact. Descriptions of its effects at the time indicated a release of power equivalent to that which might have been obtained from a thermonuclear explosion. No expedition to the site of its landing was undertaken until 1927, when the devastation found even at 40 miles from the site was almost inconceivable; but no fragments of the meteor were located despite the several huge though shallow craters which it had caused. If this meteor consisted of anti-matter an obvious explanation is at hand for the devastation found, the lack of meteoric material, and the great size reported in eye-witness accounts of its passage.

It would therefore be of interest to re-examine the site with the view of searching for short-lived radioisotopes which would have been produced by the intense γ-radiation present. The presence of such short-lived isotopes (for example, aluminium-39, manganese-53, argon-39, titanium-44) would lend strong support to the hypothesis of anti-matter.

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[1] cf. Watson, F. G., "Between the Planets" (Blakiston Co., Philadelphia, 1941).

Integration of Absorption Bands

DIFFERENTIATION of absorption bands has been dealt with fairly completely in recent years[1] and it is the purpose of this communication to consider some novel aspects of integration.

A convenient band shape for the present purpose is

$$A = \tfrac{1}{2}A_{\max.}\,(1 + \cos x)$$

where x has the extreme values $-\pi$ and π, A is the absorbance and $x \propto \nu - \nu_0$ (ν is the frequency and ν_0 corresponds to the band maximum). On integration with addition of the appropriate constant,

$$\int A\,dx = \tfrac{1}{2}A_{\max.}\,(x + \sin x + \pi) = \mathrm{F}(x)$$

The result of plotting this expression is shown in Fig. 1*b*, together with the original band, Fig. 1*a*. Band-area is a valuable quantity, since it frequently affords a better measurement of band-intensity than peak height, which depends markedly on the resolution of the spectrometer used.

The application of a second stage of integration does not seem to have been considered previously. The resulting curve can vary considerably, as shown in Fig. 1*c* and *d*, depending on which point on $\int A\,dx$ is taken as zero. If the central point be taken, ($x = 0$), then:

$$\int \mathrm{F}(x)\,dx = \tfrac{1}{2}A_{\max.}\,(\tfrac{1}{2}x^2 - \cos x + 1)$$

and the resulting curve, Fig. 1*c*, bears some resemblance to the original absorption band; but in the more useful case where the commencement of $\int A\,dx$ is taken as zero,

$$\int \mathrm{F}(x)\,dx = \tfrac{1}{2}A_{\max.}\,(x^2/2 - \cos x + \pi x + \pi^2/2 - 1)$$

and there is no such similarity (Fig. 1*d*). It is easy to see that in *all* cases $\int A\,dx$ is equal to the difference between the initial and final slope of the doubly integrated absorption band.

In a practical case, using a spectrometer with amplifier giving a d.c. output which is applied to two conventional stages of electrical integration, the final capacitor charges (or discharges) at a constant rate, assuming a steady background, until the start of the absorption band is reached, then the double integration takes place and again the capacitor discharges (or charges) at a constant rate on completion of the band and reversion to a steady background. The difference between these two steady charging rates gives a measure of the band-area, $\int A\,dx$.

The band twice integrated, and to a lesser degree that which has been integrated once, has an important advantage over the original in that the signal/noise ratio is greatly improved since, in general, noise in the output from a spectrometer amplifier occurs at a higher frequency than that of the signal. In fact, if the signal is represented by $a_1 \sin \omega_1 t$ and the noise by $a_2 \sin \omega_2 t$, after double integration the levels are $-(a_1/\omega_1^2) \sin \omega_1 t$ and $-(a_2/\omega_2^2) \sin \omega_2 t$, so that the signal/noise ratio has improved in the ratio ω_2^2/ω_1^2. This result may make the process of double integration of value in analytical work where it is necessary to measure a particular band with maximum accuracy.

A further important use for integration is to eliminate the effect of troublesome background absorption. If, for example, a small, sharp band is located on a steeply rising or falling background, this latter may be eliminated almost completely by differentiating once or twice, as may be necessary, and then reconstructing the band free from background by integrating once or twice, as required, with addition of one or two appropriate constants before or after integration.

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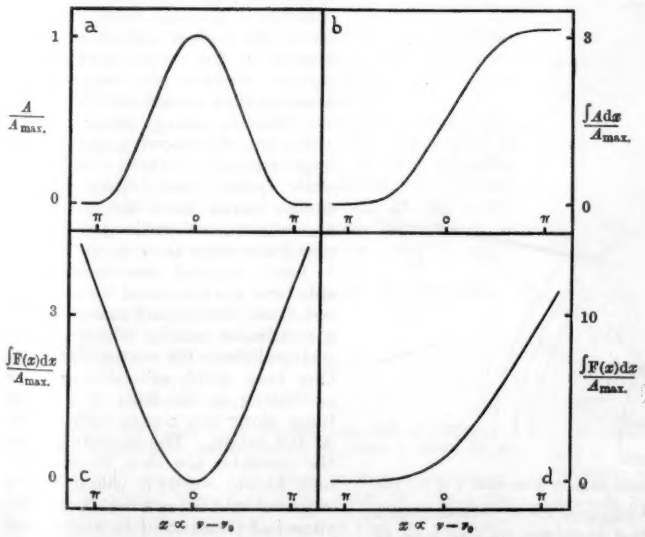

Fig. 1

Determination of Radio-Propagation Elements due to an Artificial Earth Satellite

IN a previous communication[1] an easy method was developed for determining the refraction of a radio signal-path originating in a cosmical source and penetrating the ionosphere. It was stated there that the straight-line part of a ray-path, due to the un-ionized medium, will be turned about the centre of curvature of that layer, through which it penetrates, by an angle R defined by:

$$R = \frac{\sigma}{2}\left(\frac{f^c}{f}\right)^2 \frac{\sin i_0}{\cos^3 i_0} \text{ in radians} \qquad (1)$$

or

$$R = \frac{90}{\pi}\left(\frac{f^c}{f}\right)^2 \frac{\sin i_0}{\cos^3 i_0}\,\sigma \text{ in degrees}$$

The interpretation of the symbols used as well as the limits of validity of (1) are given in ref. 1 and also in Fig. 1.

An equally simple formula has been obtained for expressing the length of a radio path between a satellite and the recorder and for determining the virtual position of the radiating body relatively to the real one.

Under the same conditions as before, we can express the length of the radio path between a satellite S and the Earth E by:

$$d = d_1 + R \sin i_0 \qquad (2)$$

where R is as defined above and i_0 and σ are the angle of incidence and the equivalent thickness of the ionized layer respectively, and $d_1 = ES'$ is, according to Fig. 1, the length of a straight line crossing the layer at the same angle of incidence i_0 between the levels ρ_E and ρ_S. Thus :

$$d_1^2 = (\rho_E)^2 + (\rho_S)^2 - 2\rho_E\rho_S \cos\varphi \qquad (3)$$

where

$$\varphi = i_E - i_S\,, \quad \sin i_E = \frac{\sin i_0}{\rho_E}\,, \quad \sin i_S = \frac{\sin i_0}{\rho_S}\,;$$

$$\rho_k = \frac{(6{,}400 + h_k)\text{km.}}{(6{,}400 + h_m)\text{km.}}$$

From (1), (2), (3) and Fig. 1, we find that the Doppler drift for radio waves must differ somewhat from the 'optical' drift. (Within the limits stated, the difference seems never to exceed 1 per cent.)

When the length of the ray path is expressed in wave-lengths (and considering the phase velocity), another term of similarly small value,

$$\delta = \frac{\sigma}{2\cos i_0}\left(\frac{f_0}{f}\right)^2 \qquad (4)$$

must be subtracted from d, and the same value must be added to d if the group velocity is taken into account.

Prolonging the straight line ES' to S'', where $SS'' = R \sin i_0 \pm \delta$, we get the virtual position S'' of the satellite S.

With regard to the Doppler effect, it is interesting to consider the movement of S along the straight line s going through S. We find that the length of a radio path, expressed by ES'', must increase in the same way as s. The 'optical' distance, however, expressed by the direct distance ES, increases less rapidly except in the case where the prolongation of s goes directly through E. But in this particular case there is no difference between the 'optical' Doppler effect and that measured on different radio frequencies.

A more detailed analysis will appear elsewhere (*Bull. Astro. Czech.*).

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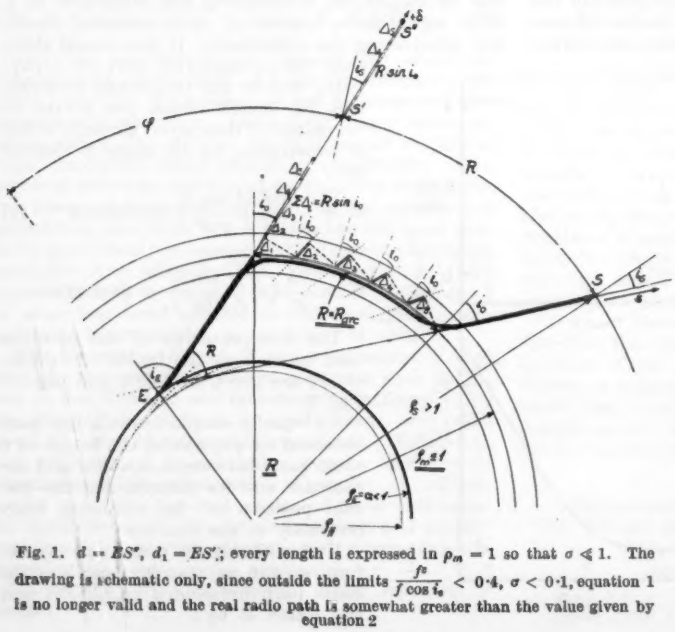

Fig. 1. $d = ES''$, $d_1 = ES'$; every length is expressed in $\rho_m = 1$ so that $\sigma \ll 1$. The drawing is schematic only, since outside the limits $\frac{f_0}{f\cos i_0} < 0{\cdot}4$, $\sigma < 0{\cdot}1$, equation 1 is no longer valid and the real radio path is somewhat greater than the value given by equation 2

Gravitational Radiation

In recent years there has been a good deal of controversy about gravitational radiation. Historically, the position is as follows. It was shown quite soon after the publication of the general theory of relativity that the linear approximation to the field equations

$$R_{ik} = 0 \qquad (1)$$

admits, in certain co-ordinate systems, solutions which have an obvious wave-like character ; moreover, it appears from the energy pseudo-tensor that these waves carry energy away from the sources, as in the electromagnetic case. According to this linear theory, waves are emitted by systems of moving masses, and the rate of transmission of energy depends on the rate of change of the moments of inertia of the system[1]. Since the field equations (1) are non-linear, these predictions of the linearized theory have to be treated with caution, and when, in 1938, a method of approximation which took account of the non-linearity was discovered by Einstein, Infeld and Hoffmann[2], it seemed that the equations of motion of particles moving under their own gravitation contained no terms which corresponded to gravitational radiation. For various reasons this could not be taken as final evidence that gravitational radiation does not exist ; but that work and some of its later developments[3] cast serious doubts on the validity of the linearized theory.

Recently, a number of exact solutions of (1) apparently representing gravitational waves have been discovered[4], but these have been inconclusive because none of them has given a clear indication of the sources of the waves, and in particular whether the sources lose mass, as they should do if the waves are carrying energy away.

I have developed a method of approximation which seems to show quite clearly that gravitational waves have the properties one expects of radiation, and in particular that they carry energy. I have applied the method to spherical gravitational waves emitted from two equal masses m in a rectilinear motion which is symmetrical about the centre of gravity. One may think of the masses as oscillating at the ends of a spring lying along the z-axis, with centre at the origin. The co-ordinates of the particles are then $(0, 0, af(t))$ and $(0, 0, -af(t))$, where a is a constant and $f(t)$ is a function of the time independent of m and a, and arbitrary except for conditions of

differentiability and for the requirement that it shall tend fairly rapidly to limits as $t \to \pm \infty$. The basis of the method of approximation is to expand the coefficients of the metric in terms of the two parameters m and a:

$$g_{ik} = \sum_{p=0}^{\infty} \sum_{s=0}^{\infty} m^p a^{2s} \overset{(ps)}{g_{ik}} \qquad (2)$$

only even powers of a occurring because of the symmetry. Taking polar co-ordinates (r, θ, φ), one proceeds to solve the field equations step by step, using (2) to expand the left-hand side of (1) in a double power series in m and a, and equating to zero each coefficient of $m^p a^{2s}$.

It is easy to see that $\overset{(00)}{g_{ik}}$ is the metric for flat space-time (in polar co-ordinates), and $\overset{(10)}{g_{ik}}$ are the corrections to this metric corresponding to a Schwarzschild solution with mass $2m$. The $\overset{(0s)}{g_{ik}}$ $(s > 0)$ are all zero, and the linear approximations come from the $\overset{(1s)}{g_{ik}}$. From the field equations for the $(1s)$ approximations one can extract a wave equation which allows one to insert solutions corresponding to retarded potentials arising from two moving masses (as for moving charges in electromagnetism). If the motion is not too rapid, the most important of these are the $\overset{(11)}{g_{ik}}$, referring to quadrupole waves. One next proceeds to the non-linear (22)-approximation and discards all terms in the field equations except those leading to terms in the $\overset{(22)}{g_{ik}}$ which are of order r^{-1} for large r, and show a permanent change, that is to say, are different at $t = \pm \infty$.

The resulting metric for the (22)-approximation can be transformed into one which for large r and $|t|$ has the form of a Schwarzschild solution of varying mass. It turns out that between $t = -\infty$ and $t = +\infty$ the system loses an amount of gravitational mass:

$$\frac{2}{15} \int_{-\infty}^{\infty} \left[\frac{d^3}{dt^3} I(t)\right]^2 dt$$

where I is the moment of inertia of the particles about the plane $z = 0$. This corresponds exactly to the energy carried away by the quadrupole waves according to the linear approximation[5].

This result seems to show beyond reasonable doubt that gravitational radiation has, according to the general theory of relativity, a real physical existence, and that it must be emitted in a wide class of particle motions. Full details of the work, and of other relevant matters, such as whether it applies to free gravitational motion, will be published elsewhere.

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Natural Airborne Radioactivity at Kjeller, Norway

We have recently been investigating airborne concentrations of radon and thoron daughters, by monitoring the β-activity of a small asbestos filter through which air is drawn at a rate of about 25 l./min. A shielded end-window counter tube is mounted above the filter, giving an overall counting efficiency of 22 per cent for potassium carbonate samples. The filter is changed daily, and decay measurements have shown that recorded activity is almost entirely due to radium *B* and *C*. Assuming equilibrium concentrations of radon and radium *A*, *B* and *C*, an equilibrium counting-rate in counts per minute can be multiplied by 0·714 to obtain an estimate of the radon concentration in curie × 10^{-18} per cm.^{3} of air.

During the last four months of 1957, radon concentrations have varied between about 30 and 1,100 × 10^{-18} c./cm.^{3} of air, with an estimated mean value of about 300 × 10^{-18} c./cm.^{3} of air.

In general our observations confirm those of other investigators, and in particular we have repeatedly noticed quite rapid increases to the highest measured values under atmospheric conditions of low inversion and low temperature. In order to explain this effect, we suggest that considerable radon exhalation may be trapped in the cooled air which tends to follow the natural water flow from the higher ground around Kjeller. This radon-enriched air then builds up in depth on the comparatively level floor of the valley. Such a mechanism might be of greater importance at more pronounced valley sites, with drainage from a larger area.

On several occasions very rapid decreases in filter activity have been recorded, which have been accom-

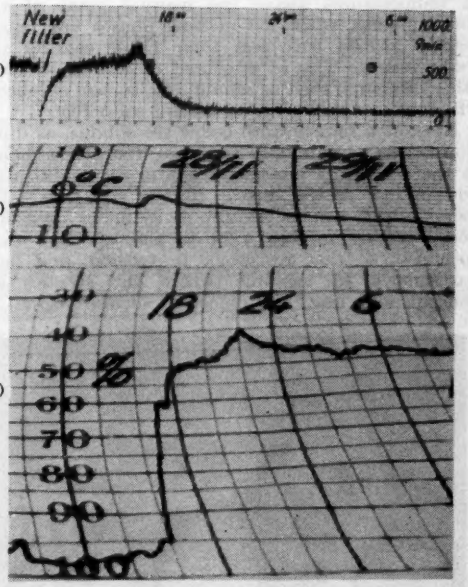

Fig. 1. Simultaneous recordings of *a*, filter activity; *b*, air temperature; *c*, relative humidity, indicating a rapid break-up of inversion conditions. The rate of decrease in filter activity is governed by the 40-min. half-life of radium *B* and *C*. The tendency for the filter activity to increase shortly before decrease has been noticed on several occasions, and may indicate the dispersal of a layer of higher activity formed during inversion conditions

panied by simultaneous changes in air temperature and relative humidity.

These investigations are being continued, and extended to other sites.

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Embrittlement of Tungsten Wires by Contaminants

Tungsten in a fully recrystallized state is well known to be brittle, but in a drawn state or even after primary recrystallization[1] is reasonably ductile and amenable to forming. This mechanically favourable state can be impaired by discontinuities in the structure, imparted by surface defects or the consequences of contamination. Disastrous contamination by traces of some metals has long been recognized in industry and the effect of nickel has been reported[2]; embrittlement by gases also has been observed[3].

The explanation of the embrittlement lies in the notch sensitivity manifested by tungsten: small surface defects or even deep etching will destroy the forming properties of wire and, conversely, electropolishing will greatly enhance these properties without loss of strength[1,4].

Even traces of iron, nickel or cobalt, owing to their low solubility in tungsten, form a local region showing a second phase (see Fig. 1) and thus exert an effect disproportionate to the extent of contamination. Attack becomes catastrophically rapid at temperatures above the melting point of the contaminants, when low-melting phases are immediately formed with less than 1 per cent of the contaminant. This is, of course, applicable to many other elements, such as aluminium, carbon or silicon, which have a slight but significant solubility.

Even at a temperature below the solidus, as diffusion of the contaminant proceeds, the phase change at the advancing interface leads to recrystallization with a loss of the ductile fibrous structure. The recrystallized regions fracture easily under stress and hence readily initiate a break through the whole specimen, so that resistance to tension, and more particularly to bending (where the stresses are concentrated near the defective surface region), is much reduced. Inspection of the equilibrium diagrams of the respective systems indicates that the effects are likely to decrease on passing from cobalt to nickel to iron. This has been found to be the case, cobalt being particularly aggressive.

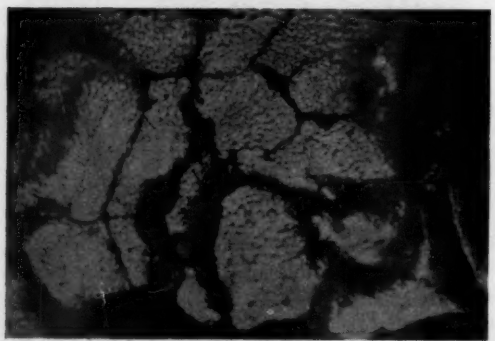

Fig. 1. Section at the surface of tungsten wire contaminated by cobalt, etched. (× 1,200)

However, this embrittlement only applies to low temperatures. Uncontaminated tungsten has a rather gradual transition from the brittle to the ductile state, which, in wires less than 0·5 mm., is usually near 200–300° C. (Elongations exceeding 20 per cent have been obtained[1] at 250° C.). Tungsten contaminated with iron and cobalt may remain brittle at temperatures up to about 700° C.

If contamination is not excessive, reasonable ductility can be restored by holding the wire at high temperatures for some time to dilute the contaminant, through its diffusion, illustrating the localization of the effect. However, there is some evidence that the 'recrystallization' temperature of the wire is lowered, so that, for certain applications, the quality of the wire is impaired.

I wish to thank Dr. J. A. M. van Moll, head of the Material Research Laboratory, and the directors of the Mullard Radio Valve Co., Ltd., for permission to publish this communication.

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Anomaly in the Age-Hardening Behaviour of Aluminium - Zinc Alloys

The very rapid hardening which occurs at room temperature after solution treatment in aluminium alloys containing about 10 per cent zinc[1] has been considered to be due to a similar mechanism to that which accounts for the hardening observed in aluminium–copper alloys aged at higher temperatures[2]. The reason for this suggestion appears to be the observations on higher zinc alloys (20–25 per cent zinc) of Geisler, Barrett and Mehl[3] and of Guinier[4] using X-ray techniques that, during the initial stages of ageing, coherent zinc-rich clusters are formed. Some recent work in these laboratories suggests that, while this explanation may be true of alloys aged at elevated temperatures, the behaviour at room temperature of alloys containing about 10 per cent zinc does not conform to that shown by other binary aluminium systems at elevated temperatures. The evidence for this view is:

(1) The extent of hardening is dependent upon the temperature within the single-phase region from which the alloy is quenched, whereas such a dependency is not observed in other precipitation hardening systems.

(2) The hardness rises to a maximum value and does not afterwards decrease in the manner of systems showing over-ageing. The high rate of hardening suggests that if this was due to a normal precipitation mechanism, then over-ageing might reasonably be expected.

(3) An alloy aged to maximum hardness at room temperature shows only a very slow decrease of hardness on subsequent ageing at 100° C. Alloys of other

systems treated in this way would show immediate reversion.

(4) As the temperature of ageing is raised, the hardness increase becomes less until no rapid hardening is detected on ageing at temperatures of about 45° C. or more. Ageing at 100° C. for very long periods (about 100 hr.) produces a hardening curve very similar to that found in other systems known to harden as the result of a precipitation process.

(5) With solutes other than zinc (for example, copper, silver, silicon, etc.) there is no difficulty, with the aid of the electron microscope, in following the precipitation which accompanies hardening. In the case of alloys containing about 10 per cent zinc no structural changes have been detected in oxide replicas prepared from samples aged to maximum hardness at room temperature.

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Antioxidant Determinations by the Use of a Stable Free Radical

Methods for measuring antioxidants and appraising antioxidant activity appear to be of two general types. If the chemical nature of the antioxidant is known, one may strive for a test specific for the compound or group of interest; for example, the nitroprusside test for sulphydryl groups. Alternatively one may observe the inhibition of some natural oxidative process such as the β-oxidation of fats, as a function of the added antioxidant.

Since a most interesting role of antioxidants, both biologically and technologically it may be supposed, is their interaction with oxidative free radicals, it appeared of interest to carry out their determination in a like manner. For this purpose we have used the stable free radical[1] α,α-diphenyl-β-picrylhydrazyl, which is generally available in laboratories in which electron spin resonance experiments are conducted, because of the paramagnetism conferred by its odd electron. It can be seen from its structure that while this compound can accept an electron or hydrogen radical to become a stable, diamagnetic molecule, it can be oxidized only with difficulty, and then, irreversibly. Because of its odd electron, α,α-diphenyl-β-picrylhydrazyl shows a strong absorption band at 517 mμ (in ethanol), its solutions appearing a deep violet colour. As this electron becomes paired off, the absorption vanishes and the resulting decolorization is stoichiometric with respect to the number of electrons taken up. The strong absorption is fortunate because the solubility of α,α-diphenyl-β-picrylhydrazyl is not great; however, alcoholic solutions having concentrations of approximately $5 \times 10^{-4} M$ are nevertheless densely coloured. In part, no doubt, because of this low concentration,

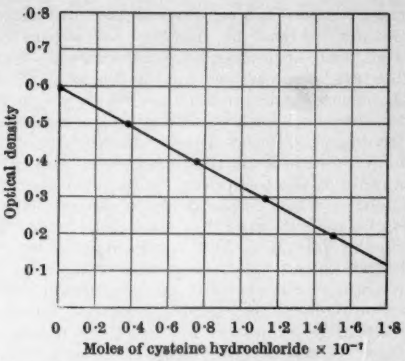

Fig. 1. A typical calibration curve showing the decolorization (at 517 mμ) of a standard α,α-diphenyl-β-picrylhydrazyl solution after addition of various amounts of cysteine and making up to a standard volume

the Lambert–Beer law is obeyed over the useful range of absorption.

The optical absorption of α,α-diphenyl-β-picrylhydrazyl is moderately stable with respect to changes in *p*H except for highly alkaline solutions, but it is found that the absorption at 517 mμ is independent of *p*H from 5·0 to 6·5, and for the best results we find it convenient to buffer the unknowns (with acetate buffers) in this range. That the predicted stoichiometry obtains is shown by a typical calibration curve, Fig. 1, for which cysteine was used as the electron donor.

Although α,α-diphenyl-β-picrylhydrazyl is loosely considered as a stable free radical, its solutions slowly deteriorate, and it is found convenient to store them under a nitrogen atmosphere in a system which allows the α,α-diphenyl-β-picrylhydrazyl to be drawn into a burette and dispensed without previously coming into contact with air. In addition, the glassware of the storage system is covered with aluminium foil. Under these conditions a standard solution may be prepared and stored with a loss of free radical activity not exceeding 2–4 per cent per week.

In its interaction with compounds having reversibly oxidizable groups α,α-diphenyl-β-picrylhydrazyl gives results consistent with the mechanisms shown in Fig. 2. It appears to be decolorized molecule for molecule by cysteine and in the ratio of two for one by ascorbic acid. In the latter case it is interesting that the free-radical intermediate of ascorbic acid is sufficiently stable to await a subsequent productive collision with a second molecule of α-α,diphenyl-β-picrylhydrazyl without, for example, undergoing a

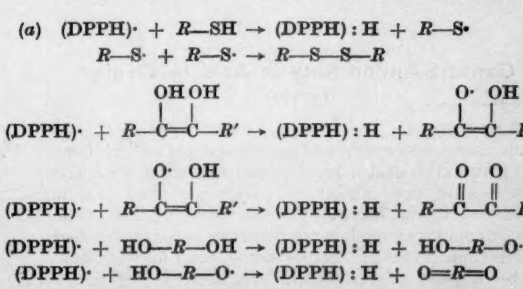
(a) (DPPH)· + R—SH → (DPPH):H + R—S·
R—S· + R—S· → R—S—S—R
(b) (DPPH)· + R—C(OH)=C(OH)—R′ → (DPPH):H + R—C(O·)=C(OH)—R′
(DPPH)· + R—C(O·)=C(OH)—R′ → (DPPH):H + R—C(=O)—C(=O)—R′
(c) (DPPH)· + HO—R—OH → (DPPH):H + HO—R—O·
(DPPH)· + HO—R—O· → (DPPH):H + O=R=O

Fig. 2. Schema of the reactions between the α,α-diphenyl-β-picrylhydrazyl radical and various oxidizable groups. (*a*) Sulphydryl groups interacting in the ratio of 1:1; (*b*) oxidation of the conjugated group of ascorbic acid to the dehydro form (2:1); (*c*) oxidation of a hydroquinone (2:1)

dimerization which would spoil the stoichiometry. The similar radical of diacetyl is sterically less hindered and undergoes a condensation, but the ascorbic acid appears within the limits of experimental observation to react only as shown in Fig. 2. In its reaction with vitamin E, α,α-diphenyl-β-picrylhydrazyl is found to be reduced in the ratio of two for one, indicating that opening of the side ring is occurring in the tocopherol under the experimental conditions. The subsequent reaction with α,α-diphenyl-β-picrylhydrazyl is essentially that of tocopherylhydroquinone. This mechanism is at present being studied and will be reported separately. Used as a reagent, α,α-diphenyl-β-picrylhydrazyl evidently offers a convenient and accurate method for titrating the oxidizable groups of natural or synthetic antioxidants. (I thank Mrs. Lina Taskowich, who performed many of these measurements, and the Carnegie Institution, Stanford, California, for use of spectrophotometric equipment.)

It has been found that α,α-diphenyl-β-picrylhydrazyl will oxidize (and be decolorized by) cysteine, glutathione, ascorbic acid, tocopherol, polyhydroxy aromatic compounds (hydroquinone, pyrogallol, etc.), and aromatic amines (*p*-phenylene diamine, *p*-aminophenol, etc.). The SH groups of proteins are oxidized, though probably not quantitatively, since proteins are precipitated by the reagent under the conditions employed. It does not have a high enough redox potential to oxidize glucose, and does not apparently under ordinary conditions oxidize purines, pyrimidines or aromatic compounds with only a single hydroxyl group, as in tyrosine, for example. Inorganic ions in lower valence states may of course interfere and must be eliminated or determined separately.

Because it measures the most common natural antioxidants, but is not interfered with by glucose, we find the α,α-diphenyl-β-picrylhydrazyl method a convenient one for the antioxidant assay of biological materials. If the antioxidant occurs to 10^{-5} molar or higher, it is unnecessary to concentrate the sample.

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Gamma-Amino-Butyric Acid in Ocular Tissue

The existence of γ-amino-butyric acid in the brain tissue was confirmed by Awapara[1], and Roberts and Frankel[2,3], and it has been identified as an active principle in the inhibitory substance that can be extracted from the mammalian brain[4]. Its occurrence in ocular tissue has not hitherto been established. The retina, however, can be considered anatomically to be a part of the brain, and from this point of view the retina, choroid, iris and cilliary body have been examined for the presence of γ-amino-butyric acid.

In this study Sanger's method[5] was applied to the qualitative microanalysis of amino-acid mixtures. Dinitrophenyl γ-amino-butyric acid was prepared by a modified form of the method of Koch and Weidel[6]. 1 gm. of γ-amino-butyric acid and a slight excess of 1-fluoro-2 : 4-dinitrobenzene were stirred with a magnetic stirrer at *p*H 9·0 (maintained by 1·0 *M* bicarbonate–carbonate buffer) and 40° C. for 80 min. Excess fluorodinitrobenzene was extracted with ether, the solution acidified with 4 *N* hydrochloric acid, and the dinitrophenyl derivatives were extracted with ethyl acetate and condensed. Dinitrophenol, which is a by-product in this process, was sublimed at 40–50° C. in vacuum for 5 min. The residue after sublimation was dissolved in ethyl acetate at 40° C., and after filtration and condensation of this solution the re-crystallization was repeated. Yellow crystals of dinitrophenyl γ-amino-butyric acid (melting point 80° C.) were obtained.

Dinitrophenyl γ-amino-butyric acid exhibited a single spot on the paper chromatogram even with several solvents (Table 1), and spectrophotometrically it showed $\lambda_{max.}$ 360mμ against a water blank. Furthermore, the position of synthesized dinitrophenyl γ-amino-butyric acid on a two-dimensional chromatogram did not coincide with that of the other dinitrophenyl amino-acids, but appeared at the intersection of the two lines, one of which was between dinitrophenol and glutamic acid and the other between alanine and glycine (Fig. 1).

Table 1. *R*F Values of Dinitrophenyl γ-Amino-Butyric Acid with Various Solvents

Solvent	*R*F value
(1) *n*-Butanol saturated with ammonia	0·40
(2) *n*-Butanol : water : ethanol (4 : 2 : 1)	0·90
(3) *n*-Butanol : acetic acid : water (4 : 1 : 5)	0·95
(4) 0·1 *M* phosphate buffer	0·66

The retina of a dog or an ox was excised, treated with absolute alcohol and heated in boiling water for 5 min. After coagulation, the sample was homogenized and centrifuged at 3,000 r.p.m. for 10 min., washed with absolute alcohol and recentrifuged. From the supernatant, containing any free amino-acids present, ethyl alcohol was evaporated at 50° C. under reduced pressure; from the residue, fatty substances were extracted with ether. The residue was subjected to two-dimensional paper

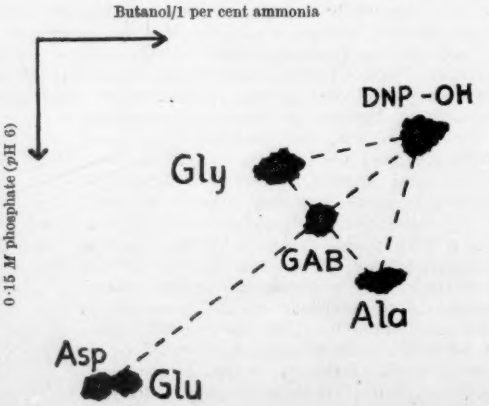

Fig. 1. Two-dimensional chromatogram of a synthetic mixture of dinitrophenyl amino-acids, especially of γ-amino-butyric acid (GAB) and related substances

Table 2. R_F VALUES OF SYNTHETIC, ELUTED AND MIXED DINITROPHENYL γ-AMINO-BUTYRIC ACID

Solvent	Synthetic	Eluted	Mixed
(1) *n*-Butanol saturated with ammonia	0·40	0·40	0·39
(2) *n*-Butanol : water : ethanol (4 : 2 : 1)	0·90	0·89	0·90
(3) *n*-Butanol : acetic acid : water (4 : 1 : 5)	0·95	0·95	0·95
(4) Pyridine : water (3 : 2)	0·82	0·81	0·81

chromatography, by Koch and Weidel's method[6]. The choroid, iris and ciliary body of dog and ox were examined in the same way.

The dinitrophenyl γ-amino-butyric acid, eluted from paper, was identical with a synthesized sample by one-dimensional paper chromatography, exhibiting a single spot even in mixed chromatography (Table 2).

γ-Amino-butyric acid was found in the retina and choroid, but not in the iris and cilliary body. The possibility that it may be produced in the former tissues by the decarboxylation of glutamic acid is being investigated.

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Effect of Calcium Ions on the Inhibition of Hydrolases by Chlortetracycline

CHLORTETRACYCLINE is an inhibitor of some enzymatic reactions[1–5]. So far as the inhibition of hydrolases is concerned, reports in the literature are contradictory[6–9]. We demonstrated in previous work that pancreatic and mould α-amylase[10,11] and pancreatic lipase are inhibited by aureomycin (Lederle). It was possible to prevent the inhibitive effect of this antibiotic substance by adding citrate, oxalate and the sodium salts of other organic acids. If, however, pure chlortetracycline was used inhibition did not occur. It was assumed that citrate prevented the inhibitive effect by removing calcium, which is present in the usual clinical Lederle preparation or in raw enzymatic preparations, from the system.

For these reasons, we studied the influence of different concentrations of calcium on the effect of chlortetracycline during enzymatic hydrolysis of starch and tributyrin. The pancreatic juice from dogs and an aqueous extract of fat-free dried hog pancreas were used as sources of lipase and α-amylase.

Dog pancreatic juice was diluted (1 : 1,000) in such a way that the amount of calcium added with the enzymatic preparation was negligible. Pure chlortetracycline containing neither calcium nor other bivalent cations was used. The enzyme was incubated with tributyrin in an acetate buffer *p*H 6·0, final concentration 0·13 *M*, and agitated for 1 hr. at 28° C.

It was found that calcium (added to the system as chloride) influences the effect of chlortetracycline during hydrolysis of tributyrin by canine pancreatic juice. Fig. 1 shows that the inhibitive effect of chlortetracycline increases with increasing concentrations of calcium. At a certain level of inhibition there is an indirect relation between the amount of calcium and that of chlortetracycline. In the absence of calcium or other bivalent cations chlortetracycline had no inhibitive effect. Similar results were obtained for hydrolysis of starch by pancreatic α-amylase. In the latter case, however, inhibition occurs only at a concentration of 200 μgm. chlortetracycline/ml. if sufficient calcium is present, whereas in the case of lipase 50 μgm./ml. already has an inhibitive effect (Fig. 1). Manganese had a similar influence on the effect of chlortetracycline on the hydrolysis of tributyrin by pancreatic lipase. Magnesium had less effect.

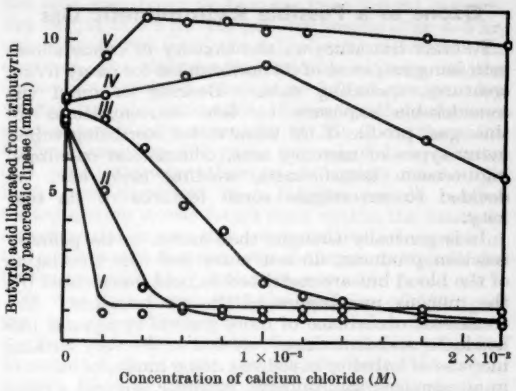

Fig. 1. I, 160 μgm.; II, 80 μgm.; III, 50 μgm.; IV, 40 μgm. chlortetracycline in 1 ml.; V, control

Some contradictory reports in the literature concerning the effect of chlortetracycline on enzymes such as lipase and α-amylase can be explained on the basis of our results, since some preparations of chlortetracycline contain calcium salts, as do also the impure enzymatic systems used by various authors when studying this question. Our previous results, showing that sodium citrate prevented the inhibitive effect of aureomycin on lipase and α-amylase, can also be explained by the removal of calcium ions from the system or a decrease in their concentration.

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Ozone as a Possible Radiomimetic Gas

Recent literature on the toxicity of ozone shows increasing suspicion of its harmfulness for many living creatures, including man. Bearing in mind the considerable exposure to low concentrations of this gas, produced by ultra-violet sterilizing tubes, many types of mercury arcs, commercial ozonizers, high-tension transformers, welding arcs, etc., we decided to investigate some features of its toxicity.

It is generally thought that ozone, or its primary reaction products, do not enter into the circulation of the blood but are restricted to, and inactivated by, the mucous membranes of the air passages. The consistent occurrence of more general symptoms like headache and drowsiness[1], as well as the very striking increase of lethality in rodents doing muscular exercise in an ozonized atmosphere[2], however, suggest a more extensive distribution. Also Stokinger's[2] important observations on the rapid development of biochemical protection against inhalation of lethal doses of ozone, persisting for several weeks, by previous sublethal doses, might be interpreted as suggesting 'deeper' receptors for this gas.

Our measurements of cutaneous oxygen consumption in man, as influenced by hyperoxia, by irradiation and by ozone inhalation offer a contribution to this problem. The method employed has been described by Lamberts[3]; its principle is the sudden occlusion of digital circulation and photoelectric estimation of the ensuing deoxygenation of oxyhæmoglobin. Normally this stagnant intracapillary deoxygenation proceeds logarithmically to complete dissociation of the oxyhæmoglobin (Fig. 1), but during partial inactivation of relevant enzyme chains, desaturation will not proceed beyond 30–40 per cent of oxyhæmoglobin.

Fig. 1*b* and *c* show this defect in biological oxidation caused by hyperoxia and by irradiation with ultra-violet ($3 \cdot 5 \times 10^3$ erg./sec. cm.^{2}). The phenomenon is quite reproducible and can be reversed rapidly. Confirmatory observations of the hyperoxia effect have been given by Matthes[4] and by Cuypers and Evrard[5].

The ultra-violet effect is considered by us to fall into the group of photodynamical reactions, the sensitization originating from natural fluorescent substances.

Both phenomena are tentatively interpreted as a reversible intoxication by 'oxygen radicals' of the final hæm enzymes group in the redox chain, the oxygen transport probably shifting to an oxygen transferase of the flavine type[6].

To the causes responsible for the production of oxygen radicals, namely, hyperoxia and photodynamic action, we were able to add a third possibility, the ozone effect, arising from production of ozone, not in the aqueous medium, but already in the irradiated air of the room. It was shown that the characteristic defect in oxygen consumption of the skin of the finger presented itself not only when the finger was irradiated but also when the subject breathed the air irradiated by a Hanau quartz mercury tube. A concentration of about 1 p.p.m. respired during about 10 min. was sufficient to decrease the capability of oxygen consumption in the epidermis of the finger (Fig. 1*d*).

The characteristic protection by cysteamine, effective in moderate X-ray irradiation[7], and also in hyperoxic decrease of oxygen consumption[5] was very active, too, in the ozone intoxication of the finger epidermis (Fig. 1*d*).

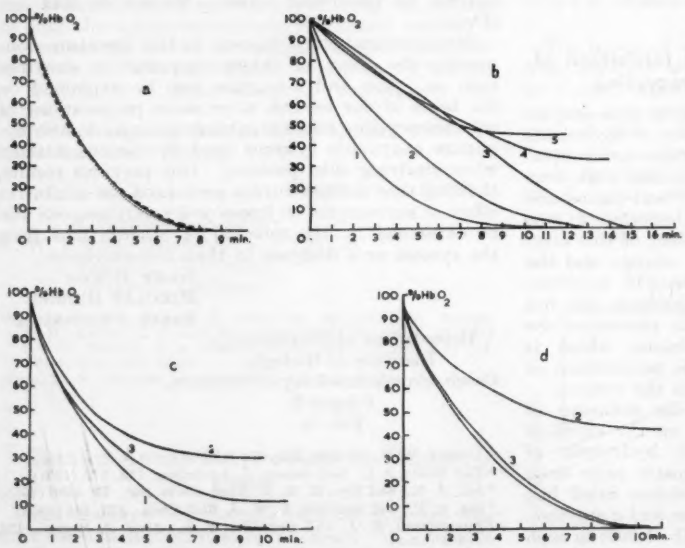

Fig. 1. Normal finger skin desaturation curves.
(*a*) Taken at intervals of 10 min., to show the reproducibility of the method.
(*b*) 1, Normal curve; 2, 3, 4, 5, desaturation curves following the breathing of pure oxygen for 2, 5, 10 and 20 min.; the increasing defect in oxygen consumption is clearly demonstrated.
(*c*) 1, Normal curve; 2, desaturation curve following irradiation with ultra-violet (360 mμ, $3 \cdot 5 \times 10^3$ erg./sec. cm.^{2}) for 10 min.; 3, desaturation curve measured 6 min. after the end of (2), indicating the reversion to the normal condition.
(*d*) 1, Normal curve; 2, desaturation curve following breathing room air with about 1 p.p.m. ozone for 10 min.; 3, desaturation curve following breathing room air with about 1 p.p.m. ozone for 10 min., after cysteamine was introduced into the skin by iontophoresis, the result being complete protection

In our opinion, the ozone effect just described suggests clearly that the inhaled gas must be responsible for the production of 'radiomimetic' symptoms in the well-perfused skin of the finger.

The ozone poisoning of biological oxygen consumption has recently been confirmed by Freebairn[8]. He demonstrated a considerable decrease in oxygen consumption in respiring fresh suspensions of mitochondria from cabbage leaves, spinach and liver cells by contact with air containing about 5 μmol. of ozone per Warburg flask. Ascorbic acid and glutathione gave protection against this effect.

Summarizing, we may conclude that: (1) in various conditions the air may contain concentrations of ozone ranging from 0·1 to 1 p.p.m.; (2) following local irritation of the lining of the airways, the reaction products may be distributed by the circulation of the blood; (3) a probable analogy between the effects of ionizing radiation and of ozone may exist, so that ozone may be a radiomimetic substance.

Direct evidence of the last supposition can be found in the recent work of Fetner[9], who exposed

seeds of *Vicia faba* to a stream of air containing 0·4 per cent weight of ozone for 15, 30 or 60 min. and then counted abnormal anaphases in the root tips when the roots had developed to 2 cm. in length. The effect of 30 min. exposure to 0·4 per cent ozone was equal to that of 100 r., and ozone plus irradiation with X-rays showed that their separate effects were fully additive. In this case, the radiomimetic effect of ozone is quite clear.

Combined with the results described earlier in this communication, the probability must be considered that inhalation of ozone, in concentrations which occur in various conditions, may lead to radiomimetic action.

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Rejection of the Peroxide Accumulation Hypothesis of Isoniazid Action

From three quite different lines of investigation it has been postulated that isoniazid kills tubercle bacilli through the intracellular accumulation of hydrogen peroxide[1–3]. In *Micrococcus lysodeikticus*, which contains an exceptionally high concentration of catalase, Chance has been able to demonstrate a peroxidase–catalase complex and to show that the peroxide concentration is controlled by the presence of suitable oxygen acceptors within the cell or added externally[4]. Sensitive though it is, Chance's spectrophotometric method would be difficult to apply to *Mycobacterium tuberculosis*, which has a very low catalase activity[5], and direct chemical determination of intracellular peroxide does not seem possible. It seemed reasonable, however, to test the theory of peroxide accumulation in the presence of isoniazid by growing the bacilli in an excess of a stable exogenous oxygen acceptor capable of penetrating the osmotic barrier of the cell but not inhibiting cell growth. Sodium nitrite appears to fulfil all the requirements in that it reduces free peroxide and reacts rapidly with the catalase–peroxide complex, both *in vitro*[6] and intracellularly[4].

It has now been shown in this laboratory that *M. tuberculosis BCG* grows well in the presence of 500 μgm. per ml. sodium nitrite in a modified Schaefer's medium[7] containing 0·5 per cent glycerol as the sole source of carbon. At the end of 10 days incubation in this medium, 80–90 per cent of the original nitrite was still demonstrable by colorimetric analysis[8]. Thus it appeared that nitrite was not metabolized by *M. tuberculosis*.

It was also possible to show by two different techniques that the nitrite passed through the osmotic barrier of the tubercle bacillus (*BCG* strain). First, using a thick suspension[9] in 0·025 *M tris*-maleate buffer at *p*H 6·8, the nitrite-impermeable volume of the cells was shown to decrease from 2·0 ml. per gm. dry weight to 0·8 ml. per gm. dry weight after 4–5 hr. exposure to 500 μgm. per ml. of sodium nitrite. In contrast, the dextran-impermeable volume of the same cells remained constant at 3·0 ml. per gm. dry weight over the same time. Secondly, the cells were shaken aerobically overnight at 37° C. in the same buffer containing 500 μgm. per ml. sodium nitrite, and were afterwards harvested, rapidly washed in buffer and disrupted in a Hughes press[10]. After centrifugation it was found that, within the limits of experimental error, the concentration of nitrite in the supernatant fraction was the same as that in the buffer to which they had been exposed.

It was then found that the addition of 500 μgm. per ml. of sodium nitrite to modified Schaefer's medium did not alter the bacteriostatic end-point of isoniazid (0·13 μgm. per ml.) for either *M. tuberculosis BCG* or *H37Rv* after 14 days incubation. Since isoniazid will not react with nitrite at *p*H 7·0, it was presumably free to induce intracellular hydrogen peroxide accumulation. Thus, if the inhibition of growth was due to this phenomenon, then the inhibitory action of isoniazid would have been antagonized by the presence of intracellular nitrite. The fact that no such antagonism was found indicates that the peroxide accumulation hypothesis of isoniazid action is untenable.

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Third Allele at the Serum β-Globulin Locus in Humans

Horsfall and Smithies[1] have recently reported evidence for the genetic control of some human serum β-globulins. Two autosomal alleles with no dominance (β^C and β^D) were proposed to account for the variable presence of the β-globulins *C* and *D*, demonstrated by two-dimensional starch-gel electrophoresis[2], in sera from Australian aborigines and Negroes[3]. No evidence was available from previous studies (made for the most part by one-dimensional starch-gel electrophoresis) for the presence of β-globulin *D* in the sera of several hundred Canadians.

Sera from 425 normal blood donors at the Toronto General Hospital have now been examined by two-dimensional starch-gel electrophoresis in order to provide more reliable evidence for the presence or absence of β-globulin *D* in the sera of Whites, since one-dimensional starch-gel electrophoresis is not satisfactory for detecting with certainty the presence of this protein. β-Globulin *D* was not observed in any of these sera, and β-globulin *C* was quantitatively the predominant β-globulin in 420 of them. However,

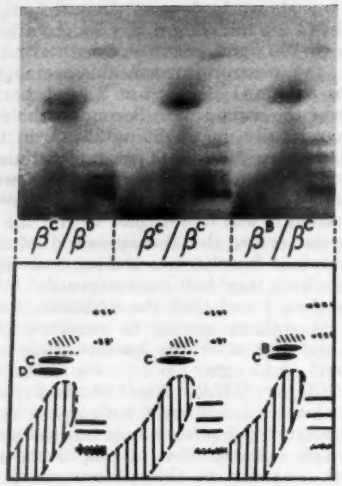

Fig. 1. Photograph and explanatory diagram of the result of a two-dimensional electrophoresis experiment on a single starch gel with the β-globulins from the sera of three individuals. On the right-hand side of the gel is a serum of the newly observed type (*βBC*). On the left and centre of the gel, respectively, are sera of the β-globulin types *βCD* and *βCC* for comparison. The β-globulins *B*, *C* and *D* are labelled in the figure, and the postulated genotypes for the illustrated types are indicated

β-globulin *B* was present in much greater amounts in the serum of five individuals than in the others, and was present to approximately the same extent as β-globulin *C*.

Fig. 1 shows a photograph and explanatory diagram of the result of a two-dimensional electrophoresis experiment on a single starch-gel with the β-globulins from the sera of three individuals. On the right-hand side of the gel is a serum of the newly observed type (β*BC*). On the left and centre of the gel respectively are sera of the β-globulin types β*CD* and β*CC* for comparison. β-Globulin *B* migrates a little more rapidly than β-globulin *C* on filter paper and in the starch gel, while β-globulin *D* migrates more slowly than β-globulin *C* in both electrophoretic systems.

The observation of this further variation in the β-globulins of normal individuals suggests that a third allele (β^B) is possible at the β-globulin locus.

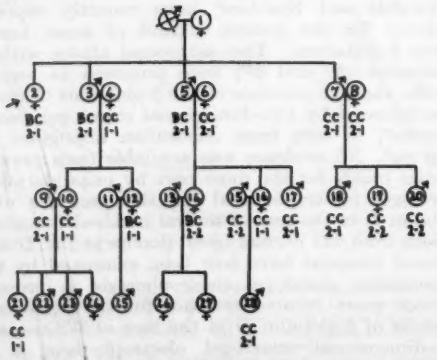

Fig. 2. The pedigree of the family of one of the five individuals in whose sera the β-globulin type *BC* was first observed. The β-globulin types of the persons whose sera were tested are indicated by the capital letters; the haptoglobin types are indicated by the numbers under the letters. The proband (No. 2) is indicated by an arrow

This allele appears to lead, when the genotype is β^B/β^C, to the presence in the serum of β-globulins *B* and *C* in equal amounts, and may well lead to the absence of β-globulin *C* when the genotype is β^B/β^B, in the same way that β-globulin *C* is absent[1] when the genotype is β^D/β^D.

Some confirmation of the correctness of this interpretation of the new serum type (β*BC*) in terms of a third allele at the β-globulin locus has been obtained. Further samples of serum from the five individuals showing the new type have been examined and the same characteristic β-globulin patterns have been obtained again. The families of these five persons are being studied, and the pattern of inheritance so far observed for the new β-globulin type is in complete agreement with the hypothesis here considered. Fig. 2 shows the pedigree of one of the families. The serum β-globulin types of the nineteen persons tested and their serum haptoglobin types[4] are indicated on the pedigree. Independent segregation of the genes at the β-globulin locus and the haptoglobin locus is seen in the offspring (10 and 12) of the individuals 3 and 4.

I am grateful to Dr. John H. Crookston, head of the Division of Hæmatology and Blood Bank, Department of Laboratories, Toronto General Hospital, for his help and the help of his staff in obtaining the blood samples used in this work, and to Mr. Otto Hiller for carrying out many of the two-dimensional electrophoresis experiments.

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Electrophoretic Behaviour of Avian Hæmoglobins

It has been previously reported[1,2] from this laboratory that in the blood of certain species of birds two electrophoretically distinct hæmoglobins can be detected, one of which has the same mobility as hæmoglobin *E* of the blood of thalassæmic patients with the genetic hæmoglobin *E* trait. This stimulated a systematic investigation of the blood of a larger number of bird species belonging to different natural orders, with regard to the electrophoretic behaviour of their hæmoglobin components.

Thirty-two species of birds belonging to thirteen natural orders varying from the older to the more recent forms[3,4] have been studied. All the samples of hæmoglobin solution, obtained as described previously[2], were subjected to electrophoresis in an *LKB* paper electrophoresis apparatus at a temperature of 4 ± 1° C. using a veronal buffer (*p*H 8·6) of ionic strength 0·05 at 220 V. for 18 hr. The unidimensional analysis was also confirmed in some cases by the two-dimensional technique[5], varying the *p*H. For comparison, blood samples of a normal adult man, of a thalassæmic patient with hæmoglobin *E* trait and of the flying mammal, the bat (*Chiroptera, Myotis*), were also investigated simultaneously on the same paper.

Altogether, five avian hæmoglobins have been detected. Fig. 1 shows the positions of all the hæmoglobin components, relative to hæmoglobins *A* and *E*.

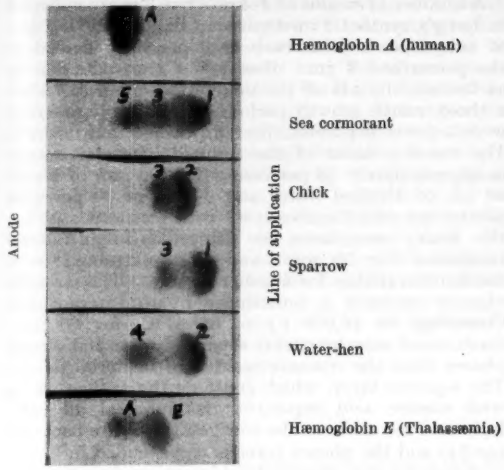

Fig. 1

The relative mobilities of the five avian hæmoglobins, which have been numbered 1–5, were 0·36, 0·46, 0·51, 0·89 and 1·00 respectively. Of these the mobilities of hæmoglobins 3 and 5 were identical with those of hæmoglobins *E* and *A* respectively.

Fig. 2 shows the electrophoretic pattern of avian hæmoglobins compared with that of bat hæmoglobin on the same electropherogram.

It will be observed that among the bird species shown in Fig. 1, the sea-cormorant (*Pelecaniformes, Phalacrocorax niger*) has three hæmoglobin components, namely, 1, 3 (*E*) and 5 (*A*). This bird species is the only one so far observed to have *A*. The majority of bird species have two hæmoglobin components: 3 (*E*) and either 2 or 1. Hæmoglobin *E* seems to exist in the older forms, namely, *Pelecaniformes, Falconiformes, Ciconiiformes*, etc., to disappear from the next forms, namely, *Cuculiformes, Gruiformes, Columbiformes*, etc., and to reappear in the most recent type the *Passeriformes*. Hæmoglobin 2 exists in the older forms and is replaced by hæmoglobin 1 in the *Passeriformes*. Some species supposed to be intermediate between the oldest and newest types have been found to have only one hæmoglobin, namely, 2, while only a few species have 4 in addition to 2.

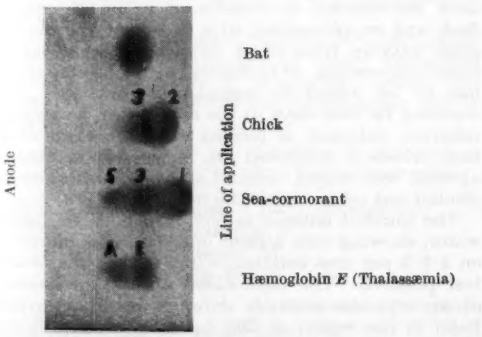

Fig. 2

Fig. 2 shows the curious identity of bat hæmoglobin with hæmoglobin *E* and not with *A* or any of the other avian hæmoglobins.

The electrophoretic identification of hæmoglobin *A* in the blood of the sea-cormorant, supposed to be one of the oldest avian species, and of hæmoglobin *E* in the blood of many old and recent bird species, and also in that of the bat, may be of some evolutionary significance. It is necessary, however, to have the identity of the hæmoglobins further examined by other techniques.

We are grateful to Dr. B. Biswas, Zoological Survey of India, for his advice and assistance in regard to the identification of the birds, to Prof. J. L. Bhaduri for discussion and to the Indian Council of Medical Research for a grant.

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Constitution of the Toxin of *Helminthosporium victoriae*

The toxin of *Helminthosporium victoriae* is one of the most potent and most specific known. As little as 0·01 μgm./ml. will completely inhibit the growth of susceptible oat roots, whereas one thousand times this concentration is needed to affect resistant plants.

The isolated toxin is very unstable. Although fresh biologically active preparations do not react with ninhydrin, this reaction is noticed as preparations lose activity. We now wish to report the nature of these materials which react with ninhydrin.

100 mgm. of the toxin prepared as previously described[1] was treated with a saturated aqueous solution of sodium bicarbonate for 24 hr. at room temperature. When the resulting solution was chromatographed on paper in propanol/acetic acid/water (200 : 3 : 100), two ninhydrin spots appeared with R_F values 0·67 and 0·84.

The material of higher R_F could be extracted from the reaction mixture with diethyl ether. After evaporation of the ether extract and solution of the residue in *N* hydrochloric acid, the compound was precipitated with a saturated aqueous solution of mercuric chloride. The mercury complex was washed with *N* hydrochloric acid and decomposed with hydrogen sulphide. The filtrate from this treatment was saturated with sodium bicarbonate and extracted with diethyl ether. When a dry ether solution of the compound was treated with ether saturated with hydrogen chloride, the material crystallized in colourless needles as the hydrochloride. After recrystallization from ethanol/ether, the hydrochloride melted at 172–73° C. (melting points were determined with a Fisher–Johns micro-melting point apparatus). A yield of 16 mgm. was obtained (calc. for $C_{17}H_{35}NOCl$: C, 68·08; H, 10·08; N, 4·67; Cl, 11·83 per cent; found: C, 68·10; H, 9·95; N, 4·58; Cl, 11·75 per cent (microanalyses by Mr. T. Bella, of the Rockefeller Institute)). A Feigl test for sulphur was

negative[2]. The compound showed only end-absorption in the ultra-violet region. It was lævorotatory; $[\alpha]_D^{25} = -78°$ ($c = 3{\cdot}2$ in 95 per cent ethanol).

This compound, for which we propose the trivial name 'victoxinine', formed a crystalline reineckate which, after recrystallization from ethanol, melted at 105–6° C. (calc. for $C_{31}H_{36}N_7OS_4Cr$: C, 43·28; H, 6·23; N, 16·83 per cent; found: C, 43·35; H, 6·13; N, 16·83 per cent). Thus, victoxinine has the empirical formula $C_{17}H_{29}NO$. It appears to be a natural product not previously described.

The second product reacting with ninhydrin (R_F 0·67) has not been investigated as extensively. It appears to be a peptide since on hydrolysis with 6 *N* hydrochloric acid the single ninhydrin spot was replaced by five spots. These were tentatively identified as aspartic acid, glutamic acid, glycine, valine and one of the leucines, by two-dimensional paper chromatography in propanol/acetic acid/water (200 : 3 : 100) followed by phenol/0·1 per cent ammonia.

The nature of the labile linkage between victoxinine and the peptide is interesting. It seems to involve the amino-groups of both victoxinine and the peptide since the toxin does not react with ninhydrin. It is more stable than an electrostatic linkage since the cleavage is not instantaneous.

Victoxinine completely inhibited the root growth of both toxin-susceptible and toxin-resistant oats at a concentration of $2{\cdot}5 \times 10^{-4}$ molar (75 μgm. of the hydrochloride per ml.). The toxin is about 7,500 times more toxic, on a weight basis, for susceptible plants. However, the toxicity for resistant plants is about the same. This suggests that the victoxinine moiety may be responsible for the toxicity of the toxin and that the specificity may be a function of the peptide portion.

An estimation of the minimum molecular weight of the toxin would be in the order of 800, assuming equimolar portions of victoxinine and a pentapeptide of the amino-acids detected.

The investigation of the structures of these degradation products is being continued.

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A Purified Complement-fixing Antigen from *Mycobacterium johnei*

The antigen most commonly used in complement fixation tests for Johne's disease is a suspension of the specific organism, *Mycobacterium johnei*. This form of antigen is not entirely satisfactory for two reasons. Like many other particulate antigens it tends to fix complement non-specifically in the presence of cattle sera in which the proteins, particularly the globulins, have become unstable during delay in shipment. In the second place, marked cross-fixation occurs with sera of cattle sensitized to avian tubercle bacilli, because Johne's bacilli contain components common to acid-fast bacteria. Attempts have been made therefore to improve the Johne's bacillus antigen by various methods of fractionation and purification. The present communication describes the method which has proved the most satisfactory to date.

A number of strains of Johne's bacillus are cultured in Long's synthetic medium containing only 1·5 gm. of anhydrous sodium carbonate per litre instead of the prescribed 3 gm. Because of the reduction in carbonate, the *p*H of the medium is 5·6–5·8. After a three-month growth period the cultures are killed with 3 per cent phenol, filtered, washed and drained. The water content of the drained bacterial masses is approximately 78 per cent. To 100 gm. of bacilli 40 ml. of distilled water and 60 ml. of 90 per cent phenol are added successively with constant stirring, the heavy suspension is subjected to ultrasonic treatment for 30 min. and then extracted in a mechanical shaker for another 30 min. The strongly viscous emulsion is centrifuged in an International Centrifuge at 16,000 r.p.m. at 5° C. for 60 min. (multispeed attachment) to separate water and phenol phases from the massive residue of bacterial debris. The aqueous layer, which contains the antigen along with nucleic acid impurities, is siphoned off carefully and set aside in the refrigerator. The bacterial residue and the phenol layer is resuspended in 30 ml. of distilled water, shaken for 15 min., and centrifuged as before. The supernatant aqueous layer is pooled with the one from the first extraction. The extracts are usually turbid because of the incomplete sedimentation of the finely dispersed phenol particles and have to be kept overnight in the refrigerator for sedimentation. Thereafter, the supernatant is decanted and the antigen precipitated by adding 4 vol. of a 2 : 1 alcohol–ether mixture. The first portion of the precipitant produces a marked turbidity which clarifies on further addition of subsequent alcohol–ether mixtures. The separation of the antigen is completed in the refrigerator within two days, when the precipitate is centrifuged off, washed and dried with absolute alcohol and ether; average yield, 120 mgm.

Although this crude preparation seems to be pure enough for use as an antigen in routine complement fixation tests, it is markedly contaminated with nucleic acids owing to the nature of the method employed for its isolation[1]. Further purification can be achieved by precipitating the nucleic acids with glacial acetic acid from a solution of the crude fraction in the following way. A 100 mgm. amount of the crude material is dissolved in 16 ml. of distilled water, the viscous and opaque solution clarified by high-speed centrifugation, and the supernatant decanted and dialysed against two changes of 1 litre of distilled water in the cold for 24 hr. To each 8 ml. of the dialysate, 13 ml. of glacial acetic acid is added, and the partly filamentous precipitate spun down. The clear supernatant is transferred to an Erlenmeyer flask and supplemented with 3 vol. of the alcohol–ether mixture, from which the antigen separates as a milky suspension. If necessary, more absolute alcohol has to be added to complete separation. After standing for two days in the refrigerator a seemingly coherent sediment is formed at the bottom of the flask which is scratched off, suspended in absolute alcohol, centrifuged, washed and dried with absolute alcohol and ether; yield, 20 mgm.

The purified antigen is readily soluble in distilled water, showing only a faint opacity. The biuret test on a 0·3 per cent solution is negative; the Molisch test positive. The ultra-violet absorption spectrum of an aqueous solution shows a broad absorption band in the region at 260 mμ even after prolonged dialysis. However, it is difficult to say as yet whether the absorption maximum at this particular spectral

region is caused by nucleic acid impurities or whether it constitutes an essential part of the antigen spectrum. A stock solution containing 3 mgm./ml. of the fraction fixes complement in dilutions as high as 1 : 6,400 with sera of cattle naturally infected or immunized with Johne's bacilli. As an antigen for routine diagnostic tests it shows less tendency to produce non-specific reactions, but is still strongly reactive with antisera containing antibodies from avian tubercle bacilli[2].

The co-operation of Dr. C. E. Rice in testing the fractions and discussing the results and of Dr. H. Konst in supplying the cultures is gratefully acknowledged. Thanks are due to Mr. F. G. Larose for his valuable technical assistance.

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Calcium Exchanges of Ehrlich Ascites Tumour Cells of Mice

Since changes in cell calcium content and metabolism have been invoked hypothetically as contributory factors, both in the irradiation syndrome[1] and in the appearance of malignancy[2], it seemed of interest to make a detailed study of calcium exchanges in the favourable material provided by the Ehrlich ascites tumours of mice.

In preliminary experiments with 8 mice bearing 9-day tumours, the mean calcium content was found to be 12·0 ± 1·3 μgm. (standard error) per 100 mgm. wet weight of packed tumour cells. This value is close to that obtained by Lansing *et al.*[3] for mouse epidermal carcinoma (9 μgm. per 100 mgm.).

When doses of about 20 μc. of a sample of calcium-45 of high specific activity were injected into the peritoneal cavity, the tumour cells rapidly became 'labelled'. Within a few minutes the radioactivity per unit wet weight of cells and fluid were approximately equal. Since no significant difference was found between calcium concentration in cells and fluid, the specific activities also must have been similar. This result indicates complete exchangeability of the cell calcium, and contrasts sharply with the results obtained by Harris[4], who studied muscles *in vitro*.

Further work in progress includes the comparative study of calcium exchanges of freely suspended non-tumour cells, and of irradiated normal and malignant cells. Details of this investigation will be published elsewhere.

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Thermal Decomposition of Some Antibiotics

As part of our programme on the thermal decomposition of antibiotics[1], additional studies have been made to include the antibiotics, aureomycin (chlortetracycline), terramycin and tetracycline.

The thermal decomposition of the antibiotics was studied by means of an automatic recording thermobalance[2]. Sample sizes ranged from 40 to 60 mgm. and were subjected to a linear heating-rate of 5·4 deg. C. per min. During the pyrolysis, a slow stream of air was passed over the sample to remove the decomposition products from the furnace.

The resulting thermograms of aureomycin, aureomycin hydrochloride, terramycin and tetracycline hydrochloride are given in Fig. 1. In general, the antibiotics studied were surprisingly stable. The thermobalance, of course, can only detect decomposition if a resulting loss in weight occurs. Using this as a criteria for establishing decomposition, the antibiotics were stable up to the 145–170° C. temperature-range.

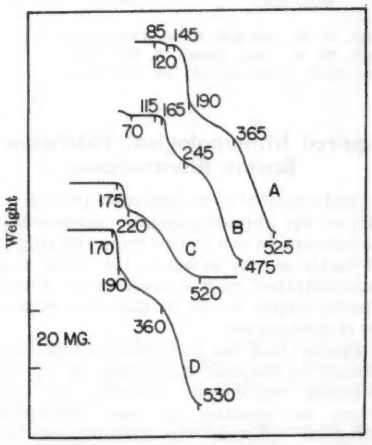

Fig. 1. Thermograms of antibiotics. *A*, Tetracycline hydrochloride; *B*, terramycin; *C*, aureomycin; *D*, aureomycin hydrochloride

Tetracycline hydrochloride (Fig. 1, curve *A*) began gradually to lose weight beginning at 85° C. From 120° to 145° C. a horizontal weight-level was observed which probably corresponded to the anhydrous antibiotic. This first loss in weight is thought to be due to loosely bound water. Beyond 145° C., total disruption and oxidation of the organic material occurred, resulting in an empty thermobalance pan at 525° C.

Terramycin (curve *B*) lost a small amount of water at a little above room temperature, giving a horizontal weight-level from 70° to 115° C. which corresponded to the anhydrous antibiotic. Rapid disruption and oxidation took place above 165° C., resulting in an empty thermobalance pan at 475° C.

Aureomycin (curve *C*) was thermally stable up to 175° C. According to Broschard *et al.*[3], the melting point of the antibiotic is 168–69° C. (uncorr.), just a little below the temperature where rapid weight loss began. Above 175° C. the antibiotic decomposed

rapidly, giving a horizontal weight-level beginning at 520° C. The composition of the curve in this horizontal level is not known, but, on a weight basis, it was 49·2 per cent of the initial antibiotic weight.

Aureomycin hydrochloride (curve *D*) began to lose weight at about the same temperature as aureomycin, namely, 170° C. Broschard *et al.*[3] have reported that aureomycin hydrochloride decomposed at ~210° C., somewhat higher than that found in this investigation. Beyond 170° C., the antibiotic decomposed rapidly, giving an empty thermobalance pan at 530° C. This behaviour was slightly different from aureomycin, for which no residue was found in the thermobalance pan.

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Acquired Immunological Tolerance to Bovine Ribonuclease

A rabbit tolerant[1] to a particular protein responds normally to an immunologically unrelated protein. Animals tolerant to one of two cross-reacting proteins respond badly or not at all to the other; this has been demonstrated with heterologous proteins, but may equally apply if one of the two cross-reacting proteins is autologous.

It is possible that the formation of auto-antibodies is prevented or limited, depending on the quantity of circulating autologous antigen, by the same mechanism as operates in the development of immunological tolerance to heterologous antigens. If this is so, the ease (effective dose-level) and permanence with which tolerance to a heterologous antigen can be induced will be influenced by the naturally acquired tolerance to autologous antigens cross-reacting with the heterologous antigen. Since serum proteins from different mammals cross-react, the acquisition of tolerance to a heterologous serum albumin may be facilitated by natural tolerance to the autologous serum albumin.

If tolerance to autologous proteins exists, and if tolerance to an autologous protein can effect the adult antibody response to a cross-reacting heterologous protein, it would follow that acquired tolerance could be more readily induced by a foreign serum protein than by other heterologous proteins; this would be due partly to the close structural relationship between serum proteins from different mammals and birds, but mainly to the large quantities of soluble autologous serum proteins which permeate all tissues. Though there are indications that acquired tolerance may be induced to taxonomically unrelated proteins[2], the majority of the successful attempts to induce acquired immunological tolerance to purified proteins have been made with heterologous serum proteins; comparisons between the effective inductive dose-levels of different proteins are not available. The induction of tolerance to bovine ribonuclease may thus be of interest: autologous ribonuclease is doubtlessly present in the animal in very much lower quantities than are albumins or the principal constituents of the globulins. The immunological homogeneity of the crystallized antigen[2] and the possibility that it may act on the nucleic acid of the immature antibody-forming cells were further grounds for its choice for this study.

Thirteen new-born rabbits of the wild type were injected with bovine ribonuclease (Armour) within a few hours of birth and afterwards at intervals of 24 hr.; the doses administered were a total of 20 mgm. in 20 daily injections, 40 mgm. in 10 daily injections and 35 mgm. in 5 daily injections. Litter mates and some of the mothers served as controls. A course of injections with ribonuclease was given both to the animals injected at birth and to the control animals when they were 7 weeks old and again when they were 11 weeks old. After the second course, the antibody content of sera from all the rabbits was examined by agglutination of tanned red cells sensitized with ribonuclease[3,4]; most (12/13) of the controls but none (0/13) of the animals injected at birth had responded to the immunization.

A similar experiment was carried out with Himalayan rabbits. Animals of four litters were treated during the first days after birth and at a later stage in their life in a manner similar to that described for the wild-type rabbits. The Himalayans respond much less readily to intravenous injections of this antigen than do wild-type rabbits[5], and the poor response of normal adult Himalayan rabbits did not allow a comparison of the relative response of the control group and of the group injected at birth. All the Himalayans were therefore given a course of injections of bovine ribonuclease in Freund's adjuvant, followed by one course of intravenous injections. After this treatment, 11/11 of the controls but only 2/6 of the animals injected at birth had responded by formation of antibody.

Acquired immunological tolerance to bovine ribonuclease had thus been induced in two strains of rabbits which differ in their normal responsiveness to bovine ribonuclease. The different mode of immunization makes it difficult to compare the response of the two groups; the higher number of responders among the Himalayan rabbits may be due to their immunization with Freund's adjuvant. We have so far no evidence that tolerance to ribonuclease is less readily induced than is tolerance to human albumin—and thus no evidence for a mechanism of facilitation. Experiments are being continued to examine the persistence of acquired tolerance to ribonuclease.

It has been suggested that the initiation of acquired immunological tolerance may involve the penetration of the antigen into a locus of the immature antibody-forming cells[6], and that this locus in adult animals is not accessible to foreign antigens. The locus could contain nucleic acid essential for antibody formation; the ribonuclease given at birth penetrating to the locus and persisting there for some time would degrade the ribonucleic acid and afterwards affect antibody response to an unrelated antigen much more profoundly than would the penetration of an antigen without the enzyme activity. The effect of the injection of ribonuclease, into new-born animals, on the adult antibody response to an unrelated antigen, was tested by measuring the antibody response to

azo human albumin in Himalayan rabbits tolerant to ribonuclease; the response was found to be similar to that of a control group. Assuming the reality of the penetration of a locus in the immature cells by an intact antigen, it may be concluded that this locus either does not contain ribonucleic acid or that the continuous integrity of the ribonucleic acid in the locus is not essential for the synthesis of antibody.

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Capacitation of Rabbit Spermatozoa

It was first reported by Chang[1] for the rabbit and by Austin[2] for the rat that, even when fertilizable tubal ova were surrounded by active spermatozoa, the latter did not penetrate the zona pellucida unless they had been in the female tract for some hours. Chang[3] showed that this delay was associated with a physiological change in the spermatozoa themselves, since he found that if the spermatozoa had been previously kept in the uterus of another female for about 6 hr., fertilization proceeded immediately when the 'capacitated' spermatozoa and ova were brought together. In the rat, 'capacitation' takes 2–4 hr.[4–6]. The following experiments show that the site of 'capacitation' is not specific, and that spermatozoa can acquire fertilizing capacity in the spayed female, in the intact male, and in organs quite unrelated to the genital system.

Rabbit semen, collected with an artificial vagina, was centrifuged, and the spermatozoa made up with 0·9 per cent saline into a suspension containing 1×10^6 to 4×10^6 motile spermatozoa per 0·001 ml. The spermatozoa suspensions were incubated for varying periods of time in whatever organ or environment the capacitating effect was to be tested. The spermatozoa were then recovered from the organs by washing out the incubated suspensions with saline solution containing 0·5 per cent of dried bovine plasma. After centrifugation, the cell concentration was adjusted to 2,000 motile spermatozoa per 0·001 ml. From this suspension, amounts varying from 0·001 to 0·005 ml. were injected into the fimbriated ends of oviducts of rabbit does that had been given intravenous ovulating injections of chorionic gonadotrophin 9½–10½ hr. previously. Both oviducts of the 34 experimental rabbits were used. One oviduct was generally injected with spermatozoa incubated *in vitro*, and the other with spermatozoa incubated *in vivo*. One uterine horn was ligated above the cervix to prevent migration of the spermatozoa from one uterine horn into the other. At 12–24 hr. after ovulation, the does were killed, and the ova were examined microscopically for cleavage and presence of spermatozoa.

Table 1. Spermatozoa incubated in Various Organs *in vivo*, and in Various Tissues *in vitro*

Site of incubation	Length of incubation (hr.)	Oviducts (No.)	Ova recovered (No.)	Ova penetrated (per cent)	Ova cleaved (per cent)
Uterus of œstrous rabbit	6	4	61	97	95
Uterus of ovariectomized rabbit	5½–7	17	223	79	74
Oviduct of ovariectomized rabbit in which spermatozoa were incubated, and into which donor-ova were later transferred	7½–10	4	28	14	11
	17	7	43	95	93
Isolated bladder, ♂ ♀	7	2	24	54	54
Isolated colon, ♂ ♀	7	3	18	94	94
Anterior chamber of the eye, ♂	7	2	23	56	56
Glandula vesicularis	6–7	3	25	80	80
Dialysis bag in uterus of an œstrous rabbit	7 and 17	4	51	0	0
Excised uterus of œstrous rabbit	7	4	39	41	41
Strips of endometrium *in vitro*	6	2	29	21	21
	18	2	13	15	15
50 per cent suspension of red blood cells	7	4	24	8	4
Uncapacitated spermatozoa, 90 per cent motile, maintained *in vitro*	6	6	69	4	4
Uncapacitated spermatozoa, 10 per cent motile, maintained *in vitro*	6	2	17	0	0

The results (see Table 1) show that nearly as many ova were fertilized when spermatozoa had been incubated in the uteri of rabbits ovariectomized one month previously as when the spermatozoa had been incubated in the uterus of an œstrous animal. In ovariectomized rabbits, very few donor-ova were fertilized unless the spermatozoa had been incubated in the host's oviducts for more than 10 hr. Spermatozoa were capacitated in isolated segments of the bladder and colon in both male and female rabbits, and in the anterior chamber of the eye and seminal vesicle (glandula vesicularis) of the male. However, spermatozoa were not capacitated when they were confined in a dialysis bag inside the uterus of an œstrous animal. Some eggs were fertilized by spermatozoa which were incubated in the excised uterus of an œstrous rabbit (the uterus having been maintained in saline at 37° C.) or in strips of endometrium removed from such a uterus maintained at room temperature. Few or no ova were fertilized by spermatozoa incubated in the presence of erythrocytes or dead spermatozoa.

The decreased proportion of fertilized ova seen in some of our experiments might have been due either to the fact that only a few spermatozoa had undergone capacitation or that the process of capacitation itself had not reached completion. The latter is believed

to be the better explanation because in any given group of eggs containing both fertilized and unfertilized ova it was possible to observe many unfertilized eggs in which spermatozoa had penetrated deeply into the zona pellucida but had not reached the perivitelline space.

We thank Dr. T. Mann for his encouragement and criticism.

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Ovulation induced in Frog with Mammalian Hormones

We have reported elsewhere[1] that fertilizable eggs for embryological studies can be obtained satisfactorily from the ubiquitous Indian skipper-frog (*Rana cyanophlyctis* Schn.). Homoplastic parenteral injections of 4–5 pituitary glands into gravid test animals brought forth viable eggs after 12–15 hr. It was our object to find out if mammalian hormones could also induce these frogs to ovulate, as there is conflicting opinion about the action of gonadotrophins on female frogs. Rugh[2] noted in this connexion that: "In general, the Anura will respond to pituitaries from other Amphibia but not from mammalian extracts of the pituitary hormone". However, Creaser and Gorbman[3] quoted authors reporting ovulation in two species of *Rana* induced by mammalian hormones. Whereas many workers have reported failure to induce *Rana pipiens* to ovulate with mammalian gonadotrophins, Wright and Hisaw[4] appear to have succeeded with mammalian pituitary gonadotrophins. Ovulation has been brought about in frogs using testosterone, progesterone and adrenal cortical hormones[5,6]. Chang and Witschi[7] suggested that cortisone and adrenocorticotrophic hormone play a supporting part in the process of ovulation in *R. pipiens* and that the ovary should be brought to a threshold by implanting one or two pituitary glands to enable the supporting agent to work. It has been assumed in explaining this action that the process of ovulation is caused by the high follicular œstrogen content, which in turn releases adrenocorticotrophic hormone from the pituitary, the latter activating the adrenal cortex to secrete cortisone which assists in ovulation.

We have been using an array of mammalian hormones to study the reaction of local frogs. The breeding season of these frogs coincides with the onset of monsoon showers (June–September) and we have not noticed any winter breeding in the skipper-frog. Our experiments started in September 1957 and are being continued. It was found that a parenteral injection of two gravid pituitary glands of the skipper-frog homogenized in distilled water is not normally capable of making these gravid frogs spawn or yield viable eggs on stripping; they require four or more glands as stated above. But two glands, when injected with 0·625 mgm. of cortisone acetate (Glaxo), made 70 per cent of the test animals spawn and yield viable eggs on stripping within 20 hr.; with only one gland, it takes longer for the frogs to yield eggs. Similar experiments using combinations of two glands with adrenocorticotrophic hormone (Dumex), serum gonadotrophin ('Antex': Dumex), chorionic gonadotrophin ('Physex': Dumex; 'Antuitrin *S*': Parke Davis), follicle-stimulating hormone (Armour), luteinizing hormone (Armour), progesterone ('Luteostab': Boots), methyltestosterone (Boots), growth hormone ('Somar': Armour) and thyroid-stimulating hormone (Armour) respectively have been tried on the skipper-frog. The frogs spawned within 20–22 hr. after receiving these hormones in combination; those receiving particularly 'Antuitrin *S*', luteinizing and growth hormones in combination spawned profusely. The eggs hatched out into tadpoles after fertilization. Apart from controls injected with progesterone and testosterone, other frogs receiving equal quantities of the other mammalian hormones did not spawn or yield viable eggs on stripping. It is extraordinary that frogs which do not normally ovulate and spawn with mammalian gonadotrophins should have reacted when growth and thyroid-stimulating hormones were used in combination with pituitary glands of the same species; these hormones are not known to be ovulating agents and this is probably the first report of these two hormones functioning as augmenting agents. That the growth hormone does not contain any ovulating factor was ascertained: it does not produce any ovulation in the skipper-frog when used in association with trypsin-digested frog pituitary gland in which the *LH*-factor has been destroyed or inactivated.

Three important results emerge from these bioassays. First, we are able to confirm the observation of Rugh[2], since our frogs also are refractory to mammalian gonadotrophins, differing thereby from those of Wright and Hisaw[4]. Fertilizable eggs can thus be obtained by homoplastic pituitary injections or by the use of synergic agents such as cortisone or growth hormone. Secondly, while it may be true that adrenocorticotrophic hormone and cortisone function in the chain reaction, as assumed by Chang and Witschi[7], the tests conducted by us lead us to infer that hormones unconnected with ovulation may also act as augmenting agents. Thirdly, androgen and progesterone can bring about ovulation in our frogs and can also act as augmenting agents. Details of these experiments will be published elsewhere.

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Effect of the Synthetic Œstrogen Stilbœstrol on Pregnancy in the Rabbit

THE object of the present investigation was to show the effect of a synthetic œstrogen, stilbœstrol, in antagonizing progesterone in the rabbit endometrium and whether it can prevent or interrupt pregnancy in this animal.

Thirty-two fertile does and four fertile bucks were available. They were derived from a pure inbred albino strain. The experiment was carried out during the natural breeding season. The does were divided into two equal groups, one of which was kept as control. The does of both groups were mated to the same four bucks. Twelve experimental does (group *A*) were injected with one dose of 1 mgm. of stilbœstrol in oily solution at varying intervals from mating up to 6 days. Laparotomies performed in this group were carried out seven days from mating to diagnose pregnancy. Four other experimental does (group *B*) were diagnosed as pregnant by abdominal palpation. They were injected with one dose of 1 mgm. of stilbœstrol in oily solution, 20 days from coitus. Laparotomies were performed in this group 25 days from mating.

The animals were kept under observation for three months, and fed *ad lib.* with concentrates and green fodder. The oily solution of stilbœstrol (B.D.H.) was given subcutaneously, in all cases.

In group *A*, subcutaneous injections of 1 mgm. of stilbœstrol in oily solution when administered at different intervals up to 6 days from coitus prevented pregnancy. Control does which were mated with the same buck showed progressive gestation and gave 4–10 normal young. Moreover, when stilbœstrol was injected in the same dose into late pregnant does of group *B* (20 days from coitus), macerated remains of fœtuses were observed in the uterus, that is, fœtuses were absorbed and pregnancy was interrupted.

Natural œstrogens are used for antagonizing the progestational-proliferating reaction on the endometrium of the rabbit. This reaction produced by 1 mgm. of progesterone is prevented by 0·5–1 mgm. of stilbœstrol[1]. In the present work, one dose of 1 mgm. stilbœstrol inhibited early pregnancy up to 6 days. In rabbits injected 6 hr. before mating, it is possible that ovulation occurred but that the ova were 'tube-locked'. In the case of the other ten does, fertilization occurred but under rapid transit (due to stilbœstrol) through the tubes, the fertilized ova might degenerate since the physiological condition of the uterus is unsuitable for the nidation and development of early-stage cells. The reception and transportation of eggs in the tubes, the reception and nourishment of blastocysts in the uterus, the optimal time for decidual formation and the maturation of eggs to stimulate decidual formation all require the participation of ovarian activity and hormonal balance at a definite stage.

In group *B*, the antagonizing action of stilbœstrol was also exerted on the endometrium of late pregnant does. This is partly due to the disturbance of the œstrogen–progesterone level in the blood, as certain levels must be kept within physiological limits throughout pregnancy. Further experiments are needed to find out the optimum levels of œstrogen–progesterone during pregnancy in different species of animals.

Egyptian does were injected subcutaneously with 1 mgm. stilbœstrol in oily solution. Pregnancy was prevented when stilbœstrol was injected at different intervals from coitus up to 6 days. Pregnancy, moreover, was interrupted when the dose was given 20 days from coitus. Lack of conception in the first case may be due to ova 'tube-locked' or to rapid transit of ova to an unprepared uterus. Absorption of fœtuses in the second case might be due to the disturbance of œstrogen–progesterone levels in the blood.

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Effect of Splenectomy on Azo Dye Carcinogenesis of Rat Liver

Schmidt[1], Lepehne[2] and others, observing a hepatic response following splenectomy, reported that reticulo-endothelial cells, especially the stellate cells, hypertrophied and proliferated in the periportal areas of liver, while Dieterich[3] found morphologically an analogical appearance in the liver of animals injected with trypan blue subcutaneously. Recently, Iwase *et al.*[4] reported an inhibiting effect of trypan blue upon carcinogenesis of the liver in rats fed with azo dye.

The present studies were concerned with the carcinogenic response of the liver in splenectomized rats to *p*-dimethylaminoazobenzene. In the experiments albino rats of mixed breed weighing 80–125 gm. underwent a total resection of the spleen and were given 0·06 per cent *p*-dimethylaminoazobenzene diet a week later. The animals were subcutaneously injected with 'mycillin' (a mixed solution of streptomycin and penicillin) daily 5–7 days after the operation with the view of preventing anæmia caused by *Bartonella muris*. The control rats were also given 0·06 per cent *p*-dimethylaminoazobenzene diet in the same way. The basal diet consisted of unpolished rice and was supplemented by green vegetables every one or two days. The *p*-dimethylaminoazobenzene ingested by each rat amounted to about 530–630 mgm. for five months; but significant difference between both groups was not noticed. All the animals were killed 150 days after azo dye administration and the incidence of liver cancer of the splenectomized rat group was compared with that of the control group macroscopically and microscopically.

The results showed that the production of liver cancer by azo dye was significantly depressed by splenectomy. This was manifested by a lowered incidence of neoplasms, namely, incidence of tumours in rats was 23·5 per cent in the splenectomy group against 76·0 per cent in the control group. In the treated group the liver generally indicated cirrhotic changes, and metastases were not recognizable in any case; whereas in the controls, tumour formation of the liver was very marked and metastases appeared comparatively frequently (26·3 per cent).

Histologically, the livers of splenectomized animals generally (though individual variation was considerable) were characterized by proliferation of the stellate cells around the portal tracts and central veins and

within sinusoids. However, interrelation between the above cell proliferation and carcinogenic changes was not always indicated morphologically, so in regard to the inhibitory effect of splenectomy, the histopathological meaning of reticulo-endothelial cell proliferation was not clear. Again, in the treated group, hyperplasia of the parenchymatous cells was inhibited while the proliferation of bile ducts accompanied by an increase of connective tissue (cholangiofibrosis and cirrhosis) was more dominant than in the controls.

Although the mechanism underlying delay of the production of liver cancer by azo dye by splenectomy is unknown, we are inclined to the view that some factor of the spleen itself plays an important part rather than that the liver reticulum cells proliferate in compensation for splenectomy.

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Increased Rate of Plaque-type and Host-range Mutation following Treatment of Bacteriophage *In vitro* with Ethyl Methane Sulphonate

Although bacteriophage undergoes 'spontaneous' mutation during the course of intracellular multiplication, it has proved difficult to increase the mutation-rate (that is, to 'induce' mutation) by artificial means. Latarjet[1] has presented evidence for an increased proportion of host-range mutants in the progeny of bacteria infected with phage *T2* as a result of ultra-violet irradiation of the complex. The proportion of host-range mutants of *T1* was found by Tessman[2] to be increased when both host cells and virus were irradiated with ultra-violet prior to infection, but not when either component alone was irradiated. De Mars[3] found an increase in the yield of plaque-type mutants when euflavine was administered during intracellular growth, and Litman and Pardee[4] achieved a similar result when phage was grown through a number of cycles in a medium containing bromouracil. No increase in the mutation-rate of phage has hitherto been reported which was the consequence of treatment of the phage alone prior to infection of the host cells. I have now been able to show that treatment of phage *T2 in vitro* with the ethylating agent ethyl methane sulphonate results in an increase in the number of mutations to the *r* and *h* genotype in the first cycle of infection of the (untreated) host organism *Escherichia coli B*.

The *r* (rapid-lysing) mutant produces a plaque with a clear halo, distinct from the turbid halo of the wild type *r+* (lysis-inhibiting). A mutation from *r+* to *r* occurring during the formation of a plaque may thus produce one having both clear and turbid zones, namely, a mottled (*m*) plaque. The 'spontaneous' rate of this mutation is, however, such that any well-developed plaque initiated by *T2r+* phage will be expected to contain some *r* particles and will thus be, in a sense, mottled. The recognition of this will depend upon the stage(s) in plaque development at which mutation occurs (the earlier, the easier) and upon the optical resolution attainable in examining the fully developed plaque.

Table 1

Treatment	Plaque counts					
	Pre-burst			Post-burst		
	Total	*m*	*r*	Total	*m*	*r*
None	5,163	4	7	3,631	5	8
Ethylene oxide	15,000	6	15	7,216	0	7
Ethyl methane sulphonate	10,753	126	26	4,870	5	45

I have examined the plaques produced by phage *T2r+* after various treatments *in vitro* and scored for *m* and *r* in the first (pre-burst) and second (post-burst) cycles of infection of *E. coli B*. Table 1 gives the results of a typical experiment in which phage treated with ethyl methane sulphonate (0·4 *M* for 20 min.) and ethylene oxide (0·1 *M* for 10 min.) were compared with untreated phage in an experiment based upon the one-step growth method[5]. Plaques were classified as *m* only when showing immediately obvious *r* characteristics superimposed upon the wild-type pattern when viewed by dark-ground illumination. The counts are thus lower than as normally scored (cf. ref. 6), but refer predominantly to mutations occurring early in plaque formation. Plaques were classified as *r* where there was no visual evidence of mottling though doubtless many were, in fact, mottled. The characterization was confirmed by picking and replating representative samples. All other plaques were counted for the total, including many the type of which was not, for various reasons, discernible.

The experimental values given in Table 1 are not selected, and, indeed, the proportion of mutants in the control is higher than usually found. The chemical treatment had no appreciable effect upon the infectivity of the phage or upon the latent period and burst size of the infected cells when infection was carried out immediately. (Doubling the dose of ethyl methane sulphonate resulted in an increased proportion of mutant plaques but only in association with a diminished burst size. A fourfold increase of the ethylene oxide dose did not alter the proportion of mutant plaques.)

Phage *T2* similarly treated, adsorbed to *E. coli B* and plated pre-burst with *B/2* gave the following (*h*) plaque counts:

Control: 404	Control: 344
Ethyl methane sulphonate: 4,741	Ethylene oxide: 571

In the course of a study of the effect of alkylating agents upon phage *in vitro* and *in vivo* (unpublished work with J. C. Stock), ethyl methane sulphonate is the first to have been found mutagenically active. Other such compounds are under investigation and a full report will be published elsewhere.

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Use of Sulphonamides in the Treatment of Pleuro-pneumonia-like Organisms in Rats

IT is generally appreciated that a lung infection of adult rats is common to most laboratory rat colonies, and it is not unusual for up to 75 per cent of a colony to be infected. In recent years the disease has been given various names, but it is usually described now as a pleuro-pneumonia-like organism infection. This merely means that it is an infectious catarrh caused by these organisms. However, no specific organisms have been isolated which could be held responsible for the disease. Normally the infection only appears in the older rats, but the very young animals may also succumb to it, probably being infected by their mothers.

The disease first appears as a coryza, and the rat sneezes frequently with a mucus discharge from the nasal passages. This is followed by anorexia and gradual loss of weight. The hair becomes roughened and the rat takes on the typical appearance of a sick animal. In the very early stages there is little apparent change in the health of the animal; in fact, a perfectly healthy-looking animal may be found to have extensive lung damage. In the later stages of the disease, breathing becomes difficult and the nose is discoloured. The brownish crusting of the nose and the same discoloration of the inner fore-arms occur shortly before death. The brown discoloration is probably a stale mixture of blood and mucus from the nose. The rat at this stage of the disease is in an emaciated condition. The incidence of otitis media in our colony of August rats was very low, although it has been reported to be associated with a pleuro-pneumonia-like organism infection[1].

There seemed to be no method of controlling this disease, which periodically flared up in an otherwise healthy colony. Two practical measures were used: the isolation of infected animals, and, more usually, the immediate killing of all sick animals. These are drastic steps to have to take if long-term experiments are in progress.

A first attempt to combat the infection with crystalline penicillin (10,000 units/rat intra-peritoneally) was ineffective. We then tried sodium sulphadimidine ('Vesadin') also by intraperitoneal injection, each rat receiving 0·1 ml. per 100 gm. body-weight. This was followed by a course of triple sulphonamide ('Trinamide'), a mixture of equal parts of sulphamerazine, sulphadiazine and sulphapyridine. This was administered as an 0·2 per cent aqueous solution in the drinking water. This 'Trinamide' treatment was continued for a period of three weeks. There was a marked increase in the general well-being of the treated animals, and a gratifyingly large drop in the mortality-rate from about 60 to 2 per cent. The high mortality figure includes those rats which were killed when symptoms of the infection were first observed.

At the moment, a controlled experiment is being undertaken to test experimentally the effectiveness of these drugs as prophylactic agents in the control of pleuro-pneumonia-like organisms in a laboratory rat colony. The results so far have been very encouraging.

The Veterinary Department of Messrs. May and Baker, Ltd., very kindly supplied us with the 'Vesadin' and 'Trinamide' used in these experiments.

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Virus-like Bodies in a Transplantable Mouse Plasma Cell Tumour

THE plasma cell tumour designated *X*5563 originated in a 22½-month-old female *C3H/He* mouse in the Cancer Research Genetics Laboratory, Berkeley, California. It was successfully transplanted by Dr. H. I. Pilgrim, and mice bearing the second transplant generation were sent to the National Cancer Institute, Bethesda, Maryland, where it was routinely transplanted every 60 days in *C3H/He* mice for several transplant generations[1,2]. Mice inoculated with the tumour were sent to us by Dr. M. Potter, of the National Cancer Institute. The tumour is now in its third transplant generation in our hands.

The morphology of the tumour has been described by Dunn[1]. Microscopically the cells are described as closely resembling normal plasma cells, each having an eccentric nucleus and, in hæmatoxylin and eosin sections, a distinct central pale area.

We have examined sections of cells from the *X*5563 plasma cell tumour after fixation in osmium tetroxide and embedding in methacrylate, by phase contrast and electron microscopy. Under phase contrast, the tumour cells appear well differentiated and retain the characteristics of normal plasma cells. In a variable, but sometimes high, proportion of the tumour cells, however, a large, dense, osmiophilic inclusion can be seen occupying a central position within the cell, a position normally associated with the Golgi apparatus. On examination in the electron microscope the inclusions are seen to consist of large numbers of round membrane-bound bodies of uniform size having a diameter about 65 mμ (Fig. 1). Higher resolution micrographs show that the central portion of the body is of uniform but variable density and that the limiting membrane is double-layered. Individual particles are indistinguishable from the intracytoplasmic form of the virus-like bodies described by Bernhard *et al.*[3] in mammary tumours in mice. So far, however, no bodies corresponding to the extracellular form described by Bernhard *et al.* and by Dmochowski and Grey[4], and also observed by us in

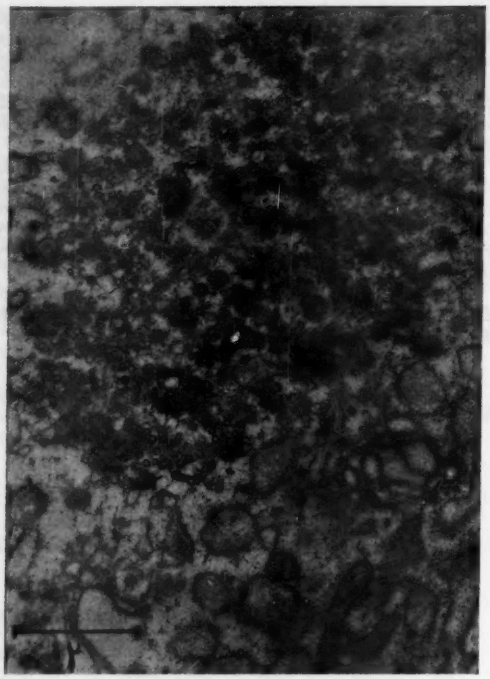

Fig. 1. Electron micrograph showing a large aggregate of virus-like bodies within the cytoplasm of a cell from the mouse plasma cell tumour *X*5563

mammary tumours in *C3H* mice, have been seen in the plasma cell tumour.

Aggregations of virus-like particles were observed in cells of tumours from two mice received from the National Cancer Institute, and in cells of tumours of two subsequent transplant generations. In all, six tumours have been studied. Similar aggregations have been observed in tumour cells in the spleen and lymph nodes of a tumour-bearing mouse. Tumour cells are easily recognized in the electron microscope as they retain the abundant rough-surfaced cytoplasmic vesicles characteristic of plasma cells (Fig. 1). No comparable aggregations of bodies of uniform size have been seen in any organs of isologous non-tumour-bearing mice that we have examined; nor have they been seen in cells of spleen and lymph node of tumour-bearing mice that were not morphologically of the plasma-cell type.

Attempts have been made in this laboratory to transmit the tumour by cell-free filtrates to new-born, and both irradiated and non-irradiated adult *C3H/He* mice. The results of these experiments are being awaited.

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Production of Convulsions in Hamsters by High Butterfat Intake

In recent studies, the effects of triglycerides containing varying amounts of saturated and unsaturated fatty acids were tested for their effect on the circulation of the cheek pouch of the hamster. In contrast to the marked changes observed in the circulation after butterfat meals[1–3], slight or no changes were observed after sesame oil meals. In addition it was noted that 4–7 hr. after butterfat meals many of the animals developed focal and then generalized convulsive seizures. Animals receiving an equal amount of sesame oil developed no seizures. This observation could be of importance in helping to decide the relative roles of saturated and unsaturated fatty acids in the genesis of acute myocardial and cerebral ischæmia due to occlusive vascular disease or inadequate circulation. Since the circulatory changes and convulsions occur under the same experimental conditions and at the same time after the fat feedings, it is possible that the convulsive seizures after butterfat meals are due to these circulatory changes. The absence of seizures after oil meals could be due to the fact that the vegetable oils, containing much more unsaturated fatty acids, affect the circulation less or not at all. This hypothesis merits serious consideration since it has already been shown *in vitro* that the ingestion of oils which contain considerable unsaturated fatty acids caused much less aggregation of red blood cells and chylomicra in dogs and man than the ingestion of fats which contain relatively more of the saturated fatty acids[1,4].

Young adult hamsters of both sexes weighing 80–120 gm. were used. Seven were fed two cream meals containing 0·8 gm. butterfat at an interval of one week. Thirty-three hamsters were pre-fed a diet containing about 46 per cent of their calories as either butterfat or sesame oil for 4 days–6 weeks, and then fed the cream or sesame oil test meals at approximately weekly intervals while still receiving the basic high fat diet in an attempt to produce seizures in all hamsters. The two high-fat basal diets contained dog chow (24 per cent protein, 8 per cent fat, and 45 per cent carbohydrate plus added vitamins, minerals and essential fatty acids) 600 gm., butterfat or sesame oil 200 gm., whole wheat flour 300 gm., salt mixture 20 gm., and a vitamin supplement (vitamin A 60,000 units, vitamin D 12,000 units, thiamin 36 mgm., riboflavin 24 mgm., pyridoxine 6 mgm., calcium pantothenate 60 mgm., niacine 120 mgm., and ascorbic acid 450 mgm.). These ingredients were baked into cakes which were fed to animals *ad lib.* The cream test meals consisted of 2·5 c.c. of cream containing 36 per cent butterfat. The sesame oil test meals consisted of 2·5 c.c. of a 36 per cent emulsion of sesame oil in skim milk. These were administered by stomach tube to animals anæsthetized with ether. The anæsthesia was so light that the animals usually began to recover before the feeding, which lasted about a minute, was completed. The seizures were recorded on 16 mm. coloured film. From these records a film with titles and captions has been prepared and this is available for study by those interested.

Five of the seven animals which received cream meals of 0·8 gm. without being pre-fed on the high butterfat basal diet, developed convulsive seizures; one after the first feeding and four after the second feeding 7 days later.

Twelve of 15 hamsters placed on the high butterfat basal diet and later tube-fed with cream containing 0·8 gm. butterfat developed seizures; none after the first cream meal, and all 12 after the second cream meal of the same size 7–14 days later. The remaining three animals received a third cream meal a week later without developing seizures.

For about 2 hr. after the test cream meal most hamsters were inactive and slept much of the time. They could be readily awakened, but just as readily relapsed back into inactivity. About 2½–3 hr. after feeding the animals became active again and moved around constantly when placed in an enclosure to be photographed. They frequently rubbed their forepaws together and rubbed their noses with one or the other forepaw.

Convulsions began to appear 4–7 hr. after the cream meal. The first seizures were of short duration, and focal in distribution. These seizures frequently appeared in the hind legs first and consisted of extensor spasms or clonic movements of one or sometimes both hind legs. The animals frequently continued to hobble about the enclosure with one leg extended rigidly lateralward from 5 to 10 sec. to as long as a minute. The tonic spasm ended, they resumed their 'normal' activity. Minutes later the seizures recurred. Usually later, and in other animals, clonic seizures of one or both forelegs and the shoulder girdle occurred. These lasted some seconds to minutes with longer intervals of relief. Clonic–tonic extensor movements of the tail with marked ventral arching of the back was often observed. Facial seizures including an ear; mastication with or without extension of the head and neck; tonic–clonic seizures of one or both sides of the trunk; and tonic contractures of the diaphragm and chest wall were noted. In all instances these were periodic at the beginning. During the seizures the animals' activity was slowed, but not stopped by the seizures. Later, periodic generalized convulsions with loss of consciousness occurred in many animals. After a few hours or several days most animals that developed seizures died.

When the seizures first developed it was possible to arrest them by sensory stimulation. Later this became increasingly difficult to accomplish. At the beginning the animals seemed normally active between seizures. Some hours later they became much less active and appeared confused. All butterfat animals remained healthy and active, without significant weight-loss, until the seizures developed. After this they lost weight and rapidly deteriorated. Only a few lived a week.

The 18 hamsters placed on the sesame oil regimen continued normally active and none developed seizures even though some were fed sesame oil diet for as long as 8 weeks and received as many as three emulsified sesame oil feedings at 1–2 weekly intervals.

Fourteen of the animals that had been on the high sesame oil basal diet for 6 weeks and had received two or three feedings of emulsified sesame oil were fed one cream meal (0·8 gm. butterfat). Six of these animals developed focal and then generalized seizures of the same severity observed after cream fat feedings alone, and three developed mild focal seizures from which they recovered in a short time. A week later a second cream meal was fed to eight survivors (five that did not have seizures, and three that had focal seizures only) and two had seizures; a total of eight severe, plus three mild seizures.

Lindsay, Finger and Henry[5] have shown that seizures precipitated by audiogenic stimuli and which are similar to those we observed after butterfat feeding, are accompanied by high-voltage sharp and slow waves of the type associated with epilepsy. It is likely that electro-encephalograms of our convulsing hamsters would have shown similar electrical activity.

These seizures occur after a large feeding of the highly saturated fat, butter, but not after feeding unsaturated sesame oil alone. Pre-feeding with sesame oil, however, seemed to predispose animals tube-fed cream to seizures. This may indicate that all lipids predispose, or may even cause seizures, but that the lipids containing highly saturated fatty acids have a greater effect than those containing unsaturated fatty acids. It seems clear that the sesame oil containing a relatively large amount of the unsaturated fatty acids did not 'protect' the animals from seizures.

Consideration might be given to the possibility that the convulsions are due to an allergy resulting from repeated cream meals. This seems unlikely since in all instances the lipids were fed by mouth, not injected; since at least six hamsters had seizures after the first cream meal; and since animals first fed oil and later cream had a high incidence of seizures. It is possible that recovery from ether anæsthesia was a factor in the production of seizures by lowering the tolerance to the stress of a fat meal. If so, this was effective only in the butterfat-fed animals.

The hypothesis that the seizures are due to physical changes in the blood resulting from the butterfat meal is at present conjectural, but in agreement with what we know of the circulatory changes in response to high butterfat intake[1–4]. Recently it has been shown in this laboratory that large butterfat meals in rabbits often cause a marked increase of the ear-to-ear circulation time, reduction in the oxygen saturation of the blood, and alteration in the size and shape of the red blood cells (Swank, R. L., unpublished work). This suggests further the possibility that the seizures are due to circulatory changes leading to ischæmia.

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Cardiac Damage caused by Experimental Stress

Psychological stimulation affects the normal cardiac function in man, causing tachycardia and vascular spasms; if these continue for a sufficiently long time, they may become, according to some workers, very important factors in the pathogenesis of some cardiovascular diseases[1]. We have studied the effect of repeated stimulation on the hearts of laboratory animals.

Table 1

Group	Heart weight (mgm./100 gm. body-weight)	Lipids (per cent in fresh tissue)	Glycogen (mgm./100 gm. fresh tissue)	Creatine (mgm./100 gm. fresh tissue)	Adenosine triphosphate (μgm./gm. fresh tissue)	Creatine phosphate (μgm./gm. fresh tissue)	Inorganic phosphorus (μgm./gm. fresh tissue)
A	338 ± 41	1·81 ± 0·13	193 ± 16	423 ± 37	351 ± 34	319 ± 27	487 ± 44
B	474 ± 59	3·09 ± 0·54	157 ± 19	358 ± 42	202 ± 26	115 ± 24	402 ± 51

15 male rats, of average weight 120–180 gm. (group *B*), were placed in individual cages in a small dark room where at irregular intervals and for a total of several hours daily they were subjected to light flashes of high intensity (100 flashes/min.; about 47 lamberts) and an electric vibrator producing sound with an intensity of about 60 phons. The two stimuli were independent of each other.

Animals were daily subjected to both types of stimulation for a total of 2–5 hr. The stimuli were sometimes applied simultaneously; the interval between the cessation of one stimulation and the beginning of the next was varied from 10 min. to 8 hr.

This treatment was carried on for five weeks. During this period the animals daily consumed a quantity of food almost equal to that consumed by the control group. At the end of the fifth week the rats were killed by bleeding, their hearts were aseptically removed, washed with saline, blotted with filter paper and weighed. The following determinations were then carried out on the hearts: total lipids, gravimetrically; creatine, according to Hawk *et al.*[2]; glycogen, according to Kahan[3]; adenosine triphosphate; creatine phosphate; inorganic phosphorus, according to La Page[4]. The same determinations were carried out on the control group (*A*) (Table 1).

These results demonstrate the effect of repeated stimulation. The heart is greatly increased in weight and its lipid content is raised; the quantities of essential metabolites of the oxidative phosphorylation process are sensibly reduced, as are those of glycogen and creatine; the effect is comparable to that seen in thyroxinized animals[5]. The metabolism of the cardiac muscle is obviously much affected.

Further researches, however, are in progress to elucidate the mechanism of their action.

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Pulmonary Arteriosclerosis due to Serotonin

Hitherto, experimental pulmonary arteriosclerosis has been induced in rabbits by the intravenous injection of fragmented blood clots prepared from their own blood or from that of another animal; either red blood clots or fibrin clots can be used[1–3]. Arteriosclerosis can also be produced by repeated injections of oxygen, nitrogen, argon or air[4,5]. We report here the production of pulmonary arteriosclerosis by serotonin.

The drug (5-hydroxytryptamine and creatinine sulphate) was injected intramuscularly or intraperitoneally into rabbits weighing 2–3 kgm. in doses of 5 mgm. every 12 hr. The injections were given for 25 days in two cycles, and suspended for a period of 35 days. Microscopic examination of the lungs revealed greater damage in the rabbits treated intramuscularly. The larger arteries of the pulmonary system showed a fibrous adherent thrombus, but the walls were not affected. The medium and small arteries showed varying degrees of fibrous-elastic intimal hyperplasia which was often asymmetrical.

Small arteries and arterioles were most affected; the lumens were much narrowed by intimal hyperplasia. Hyperplasia of the endothelium was sometimes observed. The walls of muscular arteries were thickened due to mild hypertrophy. In the arteries with intimal lesions deposits of mucopolysaccharides in the subendothelial layers were revealed by the periodic acid–Schiff reaction. Pulmonary veins were not affected.

The changes of pulmonary arteries observed after the administration of serotonin are not unique, but they are interesting in that they are caused by an endogenous substance. It has been suggested that serotonin acts as a histamine-liberator[6] and is able to induce degranulation and disruption of tissue mast cells[7], and also that the connective tissue formation caused by carcinoids and their metastases may be related to the degranulating effect of serotonin upon the mast cells[8]. The tissue œdema induced by this agent is thought to precede the release of water-binding mucopolysaccharides from the cells. Possibly, a humoral mechanism plays an important part in the etiology of pulmonary arterio-

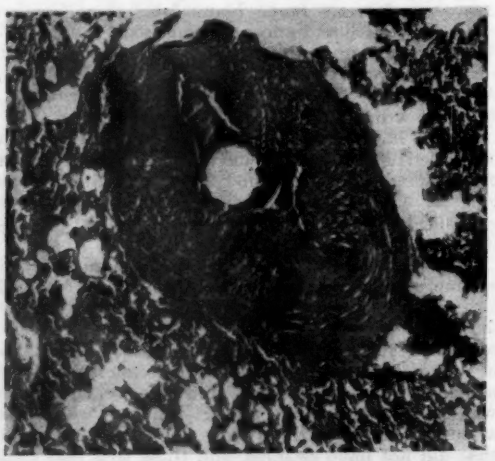

Fig. 1. Pulmonary arteries stained by positive periodic acid–Schiff reaction in subendothelial layers. (× 250)

sclerosis, in which case amines like serotonin and histamine may cause intimal lesions when their concentrations increase beyond physiological limits. The beginning of the actual mechanism of lesions remains obscure, but it looks as though the sub-endothelial deposits of mucopolysaccharides might be the answer.

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The 'Brain' Hormone in the Silkworm, *Bombyx mori* L.

The imaginal differentiation of lepidopterous insects in which diapause occurs in the pupal stage is not accomplished in one step, but the hormone secreted from the 'brain' acts upon the prothoracic gland, and the latter organ in turn secretes a hormone which induces imaginal differentiation[1,2]. On the contrary, such a system of hormonal action is not yet known in the lepidopterous insects in which diapause does not occur in the pupal stage. One of us[3,4] carried out experiments to elucidate this latter problem with the result that an imaginal differentiation in *Bombyx* silkworm in which diapause occurs in the egg-stage is induced by two hormones, the brain hormone and the prothoracic gland hormone. The former causes the latter to be secreted to induce imaginal differentiation. Further, it was made clear that the brain hormone is secreted from the neuro-secretory cells in the brain[4].

Pupæ of F_1 hybrid between two varieties, *J*.122 and *C*.115, were used and were kept at 25° C. throughout the present experiments. In ordinary pupæ of silkworm, they became imagines on the 11th–14th day after pupation, in contrast to the pupæ which are deprived of their brains immediately after pupation, in which no imaginal differentiation was observed for more than 40 days after pupation, although the operated pupæ survived for 220 days. Such a pupa was called 'Dauer-pupa' by Kobayashi[4] following Wigglesworth's[5] 'Dauer-larva'. If a fresh brain is implanted into the head of 'Dauer-pupa', it becomes an imago in 16–20 days after implantation.

From the experiment mentioned above, it is concluded that the hormone-like substance is released from the brain affecting a prothoracic gland to secrete its own hormone to induce an imaginal differentiation. This role of prothoracic gland was proved by Fukuda[6]. We have tried to obtain an effective preparation of the brain hormone as described below.

Brains of 8,500 pupæ collected within 24 hr. after pupation and stored in 60 ml. of methanol were used as the starting material. These brains were homogenized in methanol and centrifuged, and this procedure was repeated three times. 200 ml. of supernatant methanol solution was concentrated to 38 ml. and extracted with 145 ml. of ethyl ether. Ether was evaporated from the ether layer and about 2 mgm. of oily substance, yellowish brown in colour, was obtained as residue. Throughout the treatments the temperature was never allowed to rise above 38° C.

About 0·1 mgm. of the oily substance was injected into the head of each 'Dauer-pupa' about 1·1 gm. in fresh weight on the 30th day after pupation. Of five 'Dauer-pupæ' operated, one died, and the others survived, among which one on the 25th day, the remaining three on the 40th–47th day, became imagines from the injection, while not one of twenty 'Dauer-pupæ' without injection became imagines for 87 days, though they had the normal appearance of pupa during the same period.

In the second experiment 0·1 mgm. of oily substance which dissolved in 0·01 ml. of sesame oil is injected into each of four 'Dauer-pupæ' 64 days old. Among these, two pupæ died, the other two survived and became imagines in the 26th and the 43rd day after injection respectively.

In the third experiment each of four 'Dauer-pupæ', 51 days old, was injected with 0·06 mgm. of the oily substance which was dissolved in 0·0075 ml. of sesame oil. In 22 days, two died and the other two showed no sign of further development, when each of the latter two was again given 0·1 mgm. of the oily substance which was dissolved in 0·015 ml. of sesame oil. After 22–25 days from the second injection, they became moths.

Among nineteen 'Dauer-pupæ' which were used as control for the foregoing two experiments, and were not injected with oily substance, eighteen survived, remaining in a diapause state for 120 days, though one pupa became an imago on the 71st day. It is supposed that in the latter by the time when it was deprived of its brain a brain hormone already existed above threshold value for imagination.

Concerning the problem of whether the prothoracic gland hormone was contained in the oily substance or not, we think that this oily substance does not contain the hormone, because only brains were used as the source of this preparation.

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Nasal Salt Secretion in the Humboldt Penguin

The much-discussed problem of whether marine birds drink sea-water has recently led to the unexpected discovery that the kidney is not always the major organ of salt excretion. It was found that in cormorants (*Phalacrocorax auritus*) much salt may be excreted extra-renally in the form of a highly concentrated solution of sodium chloride, discharged from the nasal (salt) glands[1].

It has long been known that the bilateral nasal glands are particularly well developed in marine birds, in contrast to terrestrial birds[2]. The usual, and commonly accepted, interpretation has been

that the function of the gland is to protect the sensitive lining of the nasal cavity from the irritating or harmful effects of sea water[3,4]. However, with the knowledge that the nasal discharge has a higher salt content than sea-water, this interpretation does not seem tenable.

In the cormorant the nasal secretion contains sodium and chloride in about equivalent amounts. The nasal secretion is produced only under salt load or other osmotic stimulation, and normally the glands seem to be inactive. The rate of secretion may be rather high, up to some 0·2 ml./min., and the salt concentration between 500 and 600 m.equiv./l. If the secretion were to continue at this rate, all the sodium of the body could be eliminated in about 10 hr.

In order to establish whether extra-renal salt excretion is of importance in the salt balance of other marine birds, we took advantage of the colony of Humboldt penguins (*Spheniscus humboldti*) in the laboratory of one of us (W. S.). These birds had been caught in the wild six months before, they were doing well in captivity, and were considered to be free of disease. Trial experiments in April 1957 showed that nasal secretion of salt did occur, so the following experiment was performed. An adult male Humboldt penguin weighing 5·8 kgm. that had not fed for 21 hr. was given 5 gm. sodium chloride embedded in 56 gm. of fish (the normal daily feed for one bird is about 800 gm.). Ten minutes later drops of a clear colourless liquid appeared at the tip of the beak, and were flung off by the characteristic head-shaking movement previously observed in cormorants when they were actively secreting from the salt gland. Head-shaking is commonly seen in wild and captive penguins under a variety of conditions[5].

The discharge continued at a rate which initially was 0·36 ml./min., and over 4 hr. gradually decreased to 0·30 ml./min. The liquid was not collected after the fourth hour. At the eleventh hour nasal secretion had almost ceased. The concentrations of sodium varied from 726 to 840 m.equiv./l., of chloride from 635 to 805 m.equiv./l., and of potassium from 21 to 29 m.equiv./l. These concentrations are higher than, but otherwise in the same proportions as, in the cormorant. During the 4-hr. observation period on the penguin a total of slightly more than 80 ml. of liquid was discharged from the beak. With an average concentration of about 750 m.equiv./l., the total amount of salt elimination in this period was 60 m.equiv. (about 3·5 gm. sodium chloride). Thus, approximately two-thirds of the experimental dose of salt fed to the bird had been eliminated through the nose in 4 hr.

Nine small samples of cloacal contents were discharged during the first 4 hr. They contained very little fæcal matter as the bird was being fasted. The total volume was estimated to be about 20–40 ml. (some samples were partly lost). Concentrations in the excreta were: sodium, 40·5–209 m.equiv./l., chloride, 32–280 m.equiv./l. and potassium, 23–173 m.equiv./l. The total amount of sodium chloride eliminated by the kidney can be estimated at not more than 8 m.equiv., and probably less than one-half of this. The quantitative role of the kidney in sodium and chloride excretion in this particular experiment was then perhaps one-tenth of that of the salt glands.

It is tempting to speculate on the significance of extra-renal salt excretion in marine birds. If fish is the main food, water is available in ample amounts[1]. If invertebrates are eaten, the salt-content of the food is higher. Since the avian kidney is unable to excrete a urine with high salt concentrations, an extra-renal mechanism that can excrete highly concentrated salt solutions is advantageous. If sea-water is taken in, accidentally or for drinking purposes, the penguin can eliminate the salts from the nose at a concentration of some 700–800 m.equiv./l., well above that of sea-water (500–550 m.equiv./l.), and hence achieve a net gain in water.

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Size and Osmoregulation in Salmonid Fishes

During the course of an investigation into osmoregulation in the Atlantic salmon and two other salmonids, it has been shown that tolerance to sea-water and the ability to regulate body fluids in high salinities depends upon the size of the fish as well as on its age and species.

Three species of the genus *Salmo* have been used: *salar* L., *trutta* L. and *gairdnerii* Richardson, all hatchery-reared fish of different ages and sizes. Fish were used experimentally in batches of ten, or duplicate ones of five for larger fish, in 40-litre static tanks at constant temperature (10–12° C.) and oxygen (about 8–9 p.p.m.). Water was changed frequently to avoid the accumulation of waste products. Salinities used were those appropriate to full-strength Bay of Biscay sea-water (designated 100 per cent sea-water ≡ 33·9 per mille salinity)[1] and dilutions of this sea-water with unchlorinated bore-hole water (75, 50, 25 per cent sea-water). There was also a control static tank of 40 litres of freshwater.

The survival times of the individual fish and the freezing-point depression of the blood at certain time intervals were noted. The results shown in Table 1 are for fish immersed in 100 and 75 per cent sea-water. The blood samples for freezing-point determination were the smallest possible, and the fish appeared to suffer no ill-effects after sampling.

Table 1. Tolerance of *Salmo* Spp. to High Salinities

Species	Size (cm.)	Age (months)	Median survival time (hr.) in: 100 per cent sea-water	75 per cent sea-water
S. salar	3–4	9	2·0	10·0
S. salar	7–8	9	9·0	72·0
S. trutta	8–10	9	7·5	76·0
S. trutta	12–15	21	11·5	76·0
S. trutta	19–20	34	36·0	∝
S. gairdnerii	8–10	9	7·5	18·7
S. gairdnerii	15–20	22	120·0	∝

Table 2. Time Required for Blood Regulation

Species	Size (cm.)	Age (months)	Time (hr.) to return to normal in: 50 per cent sea-water	75 per cent sea-water
S. salar	3–4	9	200	*
S. salar	7–8	9	200	900
S. trutta	8–10	9	300	300
S. trutta	12–15	21	100	150
S. trutta	19–20	34	80	150
S. gairdneriі	8–10	9	150	400
S. gairdneriі	15–20	22	25	250

* All fish in experiment died.

The measurements were made with the micro-apparatus designed by Ramsay[2].

The smaller fish of any of the three species used were less tolerant of high salinities than were any of the larger ones. Some species difference was apparent since *S. salar* (7–8 cm.) tolerated sea-water better than did the slightly larger *S. gairdneriі* (8–10 cm.). Age alone did not account for the difference, since *S. salar* of 3–4 cm. and of 7–8 cm. were fish of the same time of hatching and had been reared in identical hatchery conditions, and yet they showed marked differences in their tolerance to sea-water.

The freezing-point depression of the blood was measured at 1, 2, 4, 8 and 24 hr. after the beginning of each experiment, and then on subsequent days. In those fish which could not tolerate high salinities the blood showed a steady rise in concentration until death (usually when the freezing-point depression of the blood was 1·0° C.). In those fish able to control, there was an initial rise in blood concentration (except in the hypo-osmotic 25 per cent sea-water) with a subsequent fall. Table 2 shows the approximate times required by the fish in 50 and 75 per cent sea-water to regulate the blood to normal concentration levels. Large fish return more quickly to normal blood-concentration levels. While the difference in rates of increase of blood concentration after immersion could reflect the change in the surface/volume ratio between smaller and larger fish, this subsequent control can only be attributed to the efficiency of the regulating mechanisms.

It is known that migrating salmon smolts of variable age are able to tolerate full-strength sea-water when they meet it in the course of the down-stream migration, and there are similar instances of brown trout and rainbow trout tolerating the direct transfer. It would seem from the experiments just described that the ability to withstand such salinity changes develops gradually during the pre-smolt life of the fish. Whether it is complete before the smolt stage is not yet known; further experiments on fish of suitable age are planned. It also appears from this evidence that the faster-growing parr are likely to develop tolerance to salt quicker than their slower-growing brethren: a conclusion supported by the evidence of some field studies that the fastest growing fish are the first to migrate as smolts[3].

The development of regulation in the young fish may be a consequence of the development of Keys–Willmer cells in the epithelium of the gills. The young newly hatched alevin, which is remarkably resistant to sea-water as well as to some poisons, is covered with an actively secreting mucous epithelium. In the fry the mucous cells appear less numerous, and a very few 'salt-regulating' cells are to be found in the gills. Later the number of these cells in the gills increases, and a fish of smolt size is fairly well provided with them. Mucous cells are much less common and are restricted to certain areas in the gill filaments.

The relation between size and other factors in development in the ability of these fish to tolerate sea-water is being studied. Some of the relevant factors appear to be the quantity and quality of the food, and the development of the 'salt-regulatory' cells. Further experiments involving these factors, as well as more comparative data for differently sized and aged fish, are in progress. A full account of the work will be published elsewhere.

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Thioctic Acid and Photosynthetic Fixation of Carbon Dioxide

Calvin and his co-workers[1] have suggested that 6,8-thioctic acid, the prosthetic group of pyruvic oxidase, is a key substance in photosynthesis, since the oxidized and reduced forms of this compound may control the distribution of the fixed carbon into the 'true' products of photosynthesis (for example, sugars) and the Krebs-cycle acids. It was proposed that thioctic acid is closely associated with the primary photochemical process[2], and experimental evidence was advanced in support of the contention that thioctic acid increases the quantum efficiency of the Hill reaction in *Scenedesmus*[3,4]. This communication summarizes the results obtained in an investigation on whether the photosynthetic reduction of carbon dioxide also is stimulated by thioctic acid.

Seven-day old cultures of *Chlorella pyrenoidosa* and *Scenedesmus obliquus* were centrifuged down at 12° C. in an *MSE* centrifuge and resuspended in 10 ml. phosphate buffer of *p*H 6·8. The cells were then incubated with different concentrations of thioctic acid and 30 μc. of sodium bicarbonate-^{14}C (68 mgm.) obtained from the Radiochemical Centre, Amersham, in a 'lollipop'-type vessel in the presence of light provided by two 1,000-watt 'Photoflood' lamps, 16 in. away from each surface. The heat was absorbed by a water-jacket maintained at a temperature of 26° C. throughout the experimental period. After 30 min., the reaction was stopped with boiling 80 per cent ethanol and evaporated to dryness. The activity was determined either in samples of saturation thickness or after resuspending the residue in 10 ml. of 80 per cent ethanol and counting 0·1 ml. aliquots with an end-window β-counter. In *Scenedesmus* approximately 13 per cent of the carbon-14 dioxide applied was fixed during the 30-min. period. It will be seen from Fig. 1 that thioctic acid failed to induce any sharp stimulation of carbon dioxide uptake in *Scenedesmus*. Concentrations greater than 250 μgm./ml. were distinctly inhibitory. Similarly, no marked stimulation of uptake of carbon dioxide was observed in *Chlorella*.

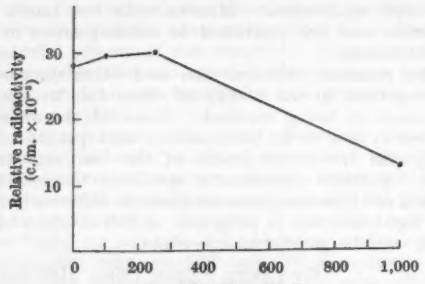

Fig. 1. Effect of thioctic acid on the fixation of sodium bicarbonate labelled with carbon-14 in light by *Scenedesmus* (counts taken in saturation thickness)

In Bradley and Calvin's experiments the stimulated rate was observed in presence of low concentrations of quinone. They presumed that thioctic acid is reduced to its thiol form and acts with quinone as a Hill oxidant. In later experiments, therefore, *Scenedesmus* cells were incubated with 0–250 μgm./ml. of thioctic acid together with 0·4 mgm./ml. of freshly sublimed quinone. It was found that, even in presence of quinone, low concentrations of thioctic acid promoted the photosynthetic uptake of carbon dioxide only slightly (Fig. 2).

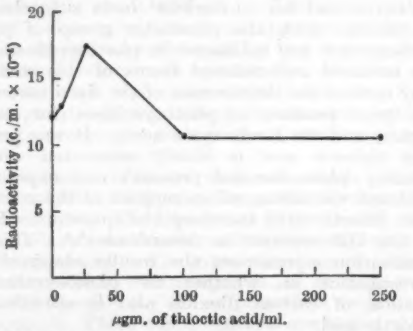

Fig. 2. Effect of thioctic acid and quinone (0·4 mgm./ml.) on the fixation of sodium bicarbonate labelled with carbon-14 in light by *Scenedesmus* (counts calculated from the results for 0·1 ml. aliquots)

To study the distribution of fixed carbon in the products of photosynthesis as affected by thioctic acid, *Chlorella pyrenoidosa* was incubated with a low concentration (25 μgm./ml.) of thioctic acid in light for 30 min. and the ethanol extracts subjected to two-dimensional paper chromatography on Whatman No. 1 filter paper with phenol/water and butanol/acetic acid/water (4 : 1 : 1)[5] as the developing solvents, followed by radioautography with 'Ilford' X-ray films. Radioactivity of the spots was determined directly on the paper. It was observed (Table 1) that with low concentrations of thioctic acid there was a larger distribution of the fixed carbon into Krebs-cycle acids than in the absence of the acid.

Table 1. Percentage of Total Carbon-14 Activity in the Alcohol-soluble Fraction

	0	25 μgm./ml.
Sugars and phosphate-esters	89·10	82·60
Krebs-cycle acids (including related amino-acids)	4·08	9·63

If the thioctic acid which entered *Chlorella* cells was completely reduced to its thiol form, greater incorporation of carbon-14 in the sugars and phosphate esters was expected. Since application of thioctic acid did not result in any significant increase in the net carbon-14 dioxide fixed, and greater activity of carbon-14 in the Krebs-cycle acids was observed, it seems doubtful whether any significant amount of the thiol form was generated in light.

Further investigations are in progress.

Our thanks are due to Dr. D. M. Bose, director, and Dr. P. K. Bose, head of the Department of Chemistry, for their interest and encouragement. Grateful acknowledgment is made to Dr. T. H. Jukes, of the Lederle Laboratories, New York, and Dr. L. J. Reed, of the Biochemical Institute, University of Texas, for a generous supply of thioctic acid.

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Time of the *S* Allele Action

The genetic systems of self-incompatibility among the homomorphic flowering plants have been broadly subdivided into two groups[1]: (1) 'gametophytic systems' in which the pollen reaction is determined by the *S* allele contained in the pollen (Leguminosae, Scrophulariaceae, Solanaceae, Gramineae) and (2) 'sporophytic systems' in which the pollen reaction is determined sporophytically by the maternal *S* genotype.

The two genetic systems of self-incompatibility are believed to differ in the time of the *S* allele action. According to Bateman[2], "sporophytic control must be determined before meiosis, and persists even when the gametophyte is independent". Brewbaker[3] accepts this hypothesis and discovered some other differential characteristics of the two systems. He found that "all the gametophytic species represent plant families having binucleate pollen grains (in which sperm formation occurs after pollen germination) while sporophytic species (with one possible exception) have trinucleate grains". However, Gramineae, which have a gametophytic system (not a sporophytic system as stated by Brewbaker), have trinucleate pollen grains. Brewbaker also did not find any causal relationship between the self-incompatibility systems and bi- or tri-nucleate pollen grains.

If, in the sporophytic system, the *S* allele reaction is already produced premeiotically, irradiation of meiotic and tetrad stages (of pollen mother cells) should not produce any seed set, since the incompatibility reaction would have already been laid down in the cytoplasm prior to meiosis and before irradiation. Rajan[4], however, obtained a high setting of seed after irradiation at the tetrad stage in the genus *Brassica*, which has the sporophytic type of self-incompatibility. It has also been noted that irradiations have no mutational effect when applied to mature pollen grains of species having either sporophytic or gametophytic systems[4–6].

The observations can be explained if it is assumed that the time of expression of *S* allele action in sporophytic systems is after nuclear division II (tetra-nucleate stage), but before the four microspores are fully separated from the common cytoplasm, whereas in the gametophytic systems the time of expression of *S* allele action is after the separation of the microspores from the common cytoplasm. This, in the sporophytic systems, would allow the specific substances (antigens ?) produced by the *S* allele from one nucleus to diffuse into the cytoplasm of others. The four microspores of a pollen mother cell would thus have the same *S* reaction irrespective of the *S* allele contained in the individual microspores. With irradiation of nuclear tetrads, a mutation in the *S* allele of one nucleus would produce a decrease, in all the four microspores, of the amount of specific substances produced by that *S* allele. Normally, each of the four microspores of a pollen mother cell gets one-half of the amount of specific substances produced by one *S* allele. After mutation in one *S* allele, this amount will be reduced to one-half of the normal amount, namely, one-fourth of the amount produced by one *S* allele. This decrease of the specific substances may not be enough to prevent completely the incompatibility reaction, but may be low enough to allow a slow germination and growth of the pollen tube. Although this would mean that a longer time would be taken for fertilization, nevertheless seed could be set. If this assumption is correct, in the sporophytic system the seed set should be, in general, up to four times the mutation-rate. The irradiation of nuclear tetrads will produce four seeds per mutation rather than one seed per mutation. The very high number of seeds produced (an average of 5 seeds out of 10 ovules per fruit at 500 r.) after X-irradiation of tetrads in the genus *Brassica* seems to support the preceding hypothesis.

In the gametophytic systems, the incompatibility is expressed as a pollen tube inhibitor whereas in the sporophytic systems it is expressed as the inhibition of pollen germination. The specific substances responsible for the incompatibility reaction in the sporophytic systems, according to the present hypothesis, are already present in the cytoplasmic material which forms the microspore wall. This produces the incompatibility reaction on contact of the pollen grains with the correspondingly specific styles, thus blocking the pollen germination. In the gametophytic systems the specific substances are laid down internally in the individual microspores after their separation from the common pollen mother cytoplasm. In this case, the pollen grain germinates and penetrates the incompatible style, but the growth of the pollen tube is stopped after the specific substances of the pollen tube and the corresponding substances of the style are brought together through diffusion or other processes.

On the present hypothesis, the species with trinucleate pollen grains are those in which the nuclear activity is slightly precocious. This change leads from gametophytic to sporophytic reaction. In Gramineaeceous species which have been studied for self-incompatibility, the cytokinesis in the pollen mother cell is successive, as opposed to simultaneous, which is found in all other species studied for self-incompatibility. Due to this condition, the self-incompatibility in these Gramineaeceous species remains gametophytic in spite of the precocious nuclear activity in the microspores leading to trinucleate pollen grains.

Although in many diploid sporophytic species[2] pseudo-self-fertility caused by end-of-season conditions, age of the plant, bud pollination or other environmental conditions is common, it is rarely met with in the diploid gametophytic species. On the present hypothesis, in the diploid sporophytic species the amount of specific substances in each pollen grain would be only one-half of that produced by each *S* allele. The high incidence of pseudo-fertility may thus be caused by an upsetting by environmental changes of a critical minimum level of specific substances. For the same reason, mutations that affect the *S* alleles only slightly and are undetectable in the gametophytic systems may be able to produce self-fertility in the sporophytic systems, thus raising the induced mutation-rate to a very high level in these species. Autopolyploidy doubles the amount of specific substances since each *S* allele will be represented twice. In the sporophytic systems, this would restore the convenient balance of specific substances found in the normally stable gametophytic systems and thus can explain the increase in the incompatibility reaction of some sporophytic species after autopolyploidy[7].

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Js, a 'New' Blood Group Antigen found in Negroes

During the performance of a compatibility test for blood transfusion, a strong incomplete antibody was discovered in the serum of a previously transfused White male patient with metastatic carcinoma. Upon testing this serum against a panel of eight different red-cell specimens of known antigenicity, it was found that only one was agglutinated. The blood-groups of this sample, which was from a Negro, were O, *NsNs*, P+, *R'r*, V−, Lu(a−b+), *kk*, Le(a−b−), Fy(a−b−), Jk(a+b−).

The patient's red cells were grouped as O, *MsNs*, P+, R_2r, V−, *kk*, Le(a−b+), Fy(a+), Jk(a+). His serum was tested with the cells of 240 White donors without a positive reaction. However, 33 out of 172 random Negro blood specimens were sensitized.

Preliminary studies on Negro families have shown the antigen to be inherited as a dominant character: in these families the antigen has been seen to segregate independently from the ABO, MNSs and Rh antigens showing that it cannot belong to these systems. Further studies are required to rule out the other blood-group systems, particularly Kell, Duffy and Kidd. However, the antibody clearly does not specifically select Negroes of the genotype Fy(a−b−), nor does it identify an allele of *K* and *k*. The frequen-

cies given above (19 per cent positive and 81 per cent negative) suggest that the gene responsible for the 'new' antigen has a frequency in American Negroes of about 0·10.

Dr. Ruth Sanger very kindly confirmed some of our findings. She pointed out that unless the antigen is found in a White family, where blood-group segregation is usually more informative, it will probably take a long time to exclude the 'new' antigen from the remaining known blood-group systems. For this reason, we propose the tentative name, Js, for the antigen, omitting a superscript a or b until such time as its proper status is delineated.

It is of interest that this patient made another antibody, anti-V, to an antigen common in Negroes but rare in Whites; the anti-V could be removed by appropriate absorption leaving the anti-Js intact.

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Cytoplasmic Variation in *Nectria stenospora*

During an investigation of the suitability of *Nectria stenospora* Berk. and Br. for the study of fungal variation, a case of cytoplasmic variation occurred which, at first appearance, closely simulated a gene-controlled effect.

The eight ascospores from a single ascus of unknown parentage were isolated on potato dextrose agar and, on the characters of colony colour and texture, were grouped into four pairs. The colour of the colony was controlled by a single pair of alleles, with 'yellow' dominant to 'pale', at least in heterokaryotic colonies. The texture of plate cultures was 'uniform', 'ragged' (uniform except at edge of plate where growth was ragged) or 'tasselled' (an intricate pattern of tassel- or fan-shaped areas of denser, sporulating mycelium separated by areas with reduced hyphal density and sporulation). It was thought that texture was controlled by genes at two loci. Colony characteristics are shown in Table 1.

Table 1. Characteristics of Colonies Derived from Ascospores of One Ascus

Ascospore colony	Characteristics	Postulated genotype
1, 2	Pale; uniform	y; a^1b^1
3, 4	Yellow; tasselled	Y; a^2b^2
5, 6	Pale; ragged	y; a^1b^2
7, 8	Yellow; ragged	Y; a^2b^1

Although these characteristics were always maintained if the strains were transferred by mycelium, analyses of colonies derived from single, uninucleate conidia have shown that only about 32 per cent of colonies derived from a 'tasselled' parent are 'tasselled', whereas about 10 per cent of colonies from 'ragged' parents are 'tasselled'. Only strains 1 and 2 ('uniform') breed true on subculturing with single conidia. The supposition that the tasselling effect must therefore be controlled by cytoplasmic particles has been confirmed by Jinks's heterokaryon test[1]. Using colour of the colony as a nuclear marker, a heterokaryotic colony, phenotypically 'tasselled', was made between strains 1 ('pale', 'uniform') and 3 ('yellow', 'tasselled'). Among colonies grown from single conidia were some combining the characters 'pale' and 'tasselled'. Thus 'tasselled' had become dissociated from the 'yellow' nucleus and associated with the 'pale'.

The 'tasselled' character must therefore be cytoplasmically controlled, and the resemblance to a two-gene effect in the original ascus is due to a fortuitous irregularity in distribution of the cytoplasmic particles among the ascospores, only strains 3 and 4 having sufficient for its expression and 1 and 2 having few or none. The presence of the particles in strains 5–8 is revealed in mono-conidial subcultures when a conidium, by chance, incorporates a greater-than-average number of particles[2].

The investigation has also revealed great variation between strains in regard to sexual reproduction, some apparently being sterile, some heterothallic and others homothallic, although preferentially outbreeding. Details of the work will be presented in full elsewhere.

This work was undertaken while one of us (A. G.) held a Commonwealth Scientific and Industrial Research Organization Australian Studentship for the Honours Year.

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A Change of Pathogenic Race in *Fusarium oxysporum* f. *pisi* induced by Root Exudate from a Resistant Host

The soil-borne fungus *Fusarium oxysporum* causes wilt in many economically important host plants and, like many plant pathogenic fungi, it consists of several specialized forms, each including a number of pathogenic races. A striking feature of *Fusarium* wilts is their sudden occurrence in crops in which they were previously unknown[1,2]. Such new disease outbreaks clearly suggest that either saprophytic forms of the fungus have become parasitic or that existing parasitic races have extended their host-range. Among genetic mechanisms already proposed to explain such changes of pathogenicity in *Fusarium* and other imperfect fungi are mutation, heterokaryosis, which allows haploid nuclei to associate in various ways, and a parasexual mechanism[3], which allows permanent genetic recombination without a sexual stage[4]. On the other hand, there is some evidence that pathogenicity can be influenced by the host. For example, Reddick and Mills[5] increased the varietal host range of *Phytophthora infestans* by successively transferring haploid zoospore cultures on to a series of potato varieties of increasing resistance to this fungus. Bawden[6], in discussing the role of plant hosts in microbial ecology, pointed out that this approach can be extended by first correlating the mechanism of resistance with the presence in the host of some toxin specific to the fungus pathogen or with the lack of some metabolite essential for its growth.

Pea wilt seemed to be a suitable subject with which to study this problem, for exudates from the roots of pea varieties that act as differential hosts for the different races of *F. oxysporum* f. *pisi* affect the spores of the three pathogenic races differentially[7]. For example, spore germination of race 1 is inhibited in root exudate from the race 1-resistant pea variety, Wilt-Resistant Alaska, whereas the growth of race 2,

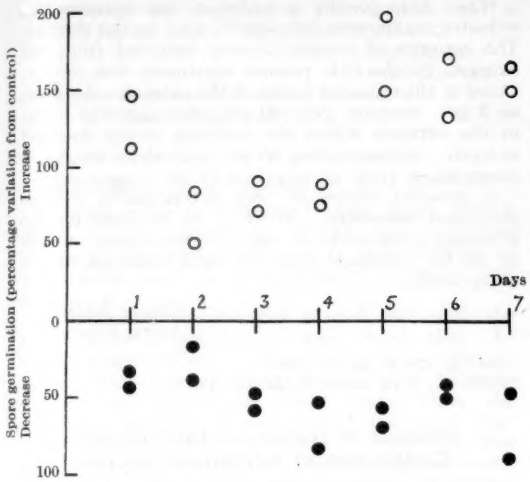

Fig. 1. Effect of root exudate from pea variety Wilt-Resistant Alaska on race 1 and race 2 of *Fusarium oxysporum* f. *pisi*. Means of two experiments. Controls in sterile glass-distilled water. ●, Race 1; ○, race 2

which can wilt Wilt-Resistant Alaska, is stimulated by the exudate (Fig. 1).

This provided an opportunity to test for a host-induced change by seeing whether retaining spores of race 1 in the root exudate would affect their ability to infect and wilt variety Wilt-Resistant Alaska.

Aliquots of 10^6 spores, from ten-day-old cultures, in 0·5 ml. sterile glass-distilled water were separately added to each of a series of test-tubes containing 0·5 ml. of sterile root exudate. Each culture was obtained from an isolate of single-spore origin, thereby ensuring uniform genetic purity. In control treatments, the spores were added to sterile glass-distilled water. In one type of experiment the spores were incubated in exudate at 25° C. for fourteen days, after which they were washed in sterile water by centrifuging, cultured in liquid Czapek–Dox medium for four days and then inoculated to pea seedlings, variety Wilt-Resistant Alaska, one plant per 4-in. pot of unsterile soil. In another type of experiment spores were retained for two days in exudate, then washed and transferred to exudate twice as concentrated. Further transfers were made every 48 hr. for fourteen days into exudates with concentrations increased by a factor of two each time, and at the end of the experiment the spores were tested for pathogenicity to Wilt-Resistant Alaska. Both types of experiment, each of which was repeated five times, gave similar results.

Fig. 2 shows that, after fourteen days in the root exudate, race 1 behaved like race 2 in that it wilted Wilt-Resistant Alaska, whereas it failed to do so after the same period in sterile water. These results leave little doubt that the pathogenicity of the race was altered by the incubation in the root exudate, and also suggest that the pathogenicity was enhanced more by the concentrated than by the dilute exudate.

Not only was pathogenic race 1 induced to increase its host-range to include variety Wilt-Resistant Alaska, but also its normal 100 per cent ability to wilt variety Onward was impaired. After its spores were retained for fourteen days in exudate, it caused only 38 per cent wilt twenty days after inoculation, against 59 per cent with race 1, which had been kept in sterile water; after a further twenty days the levels of wilt were 73 and 100 per cent respectively.

In order to test whether the adapted race 1 isolates retained their ability to wilt variety Wilt-Resistant Alaska over a period of time, re-isolations and re-inoculations have been made on seven successive occasions. All the isolates retained their virulence and, furthermore, each consistently caused wilt at the two different levels shown in Fig. 2.

One problem inherent in this particular example of adaptation for pathogenicity is whether or not the change is related to any alteration in the ability of spores to germinate in root exudate of Wilt-Resistant Alaska when they are kept in it over a period of time. Clearly an increase in the ability to germinate near root surfaces would be an advantage to a potentially pathogenic soil-borne fungus. However, counts of germination of spores each day during a period of fourteen days retention in exudate showed that no such increase occurred, notwithstanding the fact that spores from the same aliquots were able to wilt variety Wilt-Resistant Alaska at the end of the experiment. This lack of correlation between the acquired increase in pathogenicity and spore germination adds yet a further complication to the nature of the root exudates. Their already dual role enables them to enhance race 1 virulence towards a resistant variety while at the same time lowering its virulence to a susceptible one. Further work may reveal whether spore germination is controlled by inhibitory substances in the exudate that differ from those which control differences in host resistance and susceptibility to their germ tubes.

Changes of the kind described here, induced as a result of exposure to a specific substrate, are common in bacteria[8,9], and the explanations offered for these might equally well apply to pathogenic fungi. For example, the change from race 1 to race 2 pathogenicity could result from a mutation at any time during the fourteen-days exposure to the exudate. Whether such mutants occurred at random or were

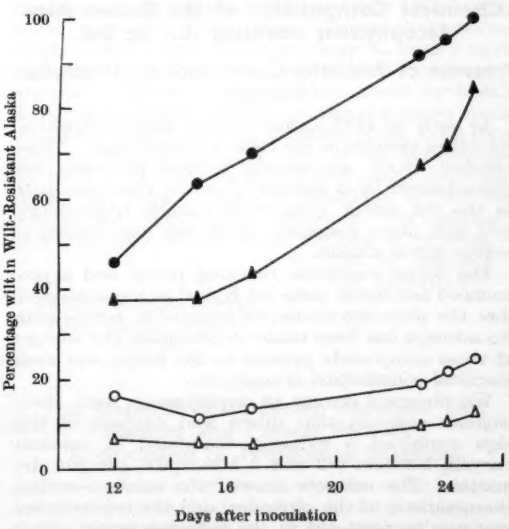

Fig. 2. Wilt caused by *Fusarium oxysporum* f. *pisi* race 1 after 14 days retention in root exudate from pea variety Wilt-Resistant Alaska. ●, retained in exudate at a concentration 4 × normal; ▲, retained in exudate at normal concentration; ○, retained in sterile glass-distilled water; △, uninoculated

actually induced by some mutagenic agent in the exudate, any with race 2 ability would be favourably selected and would tend to predominate. However, randomly occurring mutants would presumably also appear in the control treatments, but the results of the inoculation experiments indicated that this did not happen. Hence, if the change resulted from mutation, the mutants seem to have been caused by the exudate.

It seems equally likely that the phenomenon depends on a system similar to that of adaptive enzyme formation in bacteria. Such a system might act in either of two ways, depending on whether host resistance is governed by the presence of toxins or by the lack of nutrients essential to the fungus. The first would be the production of an enzyme able to detoxify the root exudate. The second would be the development of an enzyme that increased the ability of the fungus to use nutrient materials from the resistant host that previously were unavailable to it.

Whatever the mechanism underlying this apparently adaptive change in pathogenicity, it seems to illustrate yet another method by which pathogenic fungi may alter their virulence, independently of sexual methods of recombination.

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Chemical Composition of the Brown Alga *Ascophyllum nodosum* (L.) Le Jol.

Presence of Reducing Compounds in *Ascophyllum nodosum*

As early as 1893, Crato[1] noticed highly refractive, colourless vesicles in the cells of brown algae. These vesicles, which are usually termed physodes, are characterized by a number of colour reactions, such as the red colour given with vanillin hydrochloric acid and diazo reagents. They are also known to reduce silver nitrate.

The colour reactions, reducing power and a pronounced astringent taste led Kylin[2] to the conclusion that the physodes contained tannin-like compounds. No attempt has been made to determine the amount of these compounds present in the algae, and their chemical constitution is unknown.

We observed during an investigation with *Ascophyllum nodosum* that dilute acid extracts of this alga contained a reducing compound in amounts varying between 0·2 and 2·2 m.equiv. per gm. dry matter. The extracts showed the colour reactions characteristic of the physodes, and the colour intensity was proportional to the reducing power. It is therefore highly probable that the reducing compounds are identical with the compounds present in the physodes.

When hide powder is added to the extracts the reducing compounds are adsorbed on to the powder. The amount of organic matter removed from the extracts by the hide powder treatment was proportional to the reducing power of the extracts. As much as 9 gm. 'tannins' per 100 gm. dry alga was found in the extracts where the reducing power was 2·2 m.equiv., corresponding to an equivalent weight of about 40.

A detailed report of this investigation will be published elsewhere. Work is in progress on the reducing compounds of other brown algae, as well as on the chemical structure and reactions of the compounds.

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Influence of Habitat on the Chemical Composition of *Ascophyllum nodosum*

In the previous communication, we reported the presence of reducing compounds in *Ascophyllum nodosum*. It was observed that the amounts of these reducing compounds varied in samples collected at different habitats. Plants growing outside or in the outer parts of the Trondheimsfjord, collected in July, showed a reducing power of approximately 2·2 m.equiv. per gm. dry matter. In the inner parts of the fjord the reducing power was lower and reached a minimum of 0·3 m.equiv. in the neighbourhood of Trondheim, where the salinity was low due to fresh water from a river outlet. The results suggested that variations in the salinity were responsible for the variation in reducing power. To test this point samples of *Ascophyllum nodosum* were collected at different localities in Follafjord (series *A*), in Trondheimsfjord between the Rivers Nidelva and Gaula (series *B*), and at one locality in the inner part of Oslofjord. The reducing power of the samples (m.equiv. per gm. dry matter) are shown in Table 1, together with the niacin and biotin contents (μgm. gm. dry matter).

Follafjord is a threshold fjord with a river outlet at the bottom end. In series *A*, localities 1, 2, 3 and 4 lie on the outer side and localities 5, 6, 7 and 8 on the inner side, of the threshold. In series *B*, locality 1 is near the outlet of the River Gaula and locality 6 near the outlet of the River Nidelva.

The results indicate strongly that the salinity of the sea-water has a pronounced influence on the chemical composition of *Ascophyllum nodosum*. The correlation between salinity and chemical composition

Table 1

Locality		Reducing power	Niacin	Biotin
Series *A*	1	1·57	10·5	0·12
	2	2·15	9·5	0·11
	3	2·02	9·5	0·12
	4	1·89	9·0	0·09
	5	0·36	14·0	0·23
	6	0·37	14·5	0·23
	7	0·24	15·5	0·24
	8	0·27	16·0	0·28
Series *B*	1	0·18	15·0	0·44
	2	0·26	12·5	0·26
	3	0·89	10·0	0·20
	4	1·22	12·0	0·13
	5	0·79	17·0	0·23
	6	0·14	22·0	0·41
Oslofjord		0·11	19·5	0·45

of seaweeds will be further investigated, and a detailed report will be published elsewhere.

ARNE HAUG
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Trondheim. Feb. 19.

Occurrence of D-Acylase in Soil Bacteria

IN work reported earlier[1], it was shown that a strain of *Pseudomonas* sp., *KT*83, can hydrolyse N-benzoyl derivatives of both L- and D-forms of amino-acids such as phenylalanine, tyrosine and alanine.

In a further experiment[2] carried out with the *KT*83 acetone powder, it was found that the N-dichloroacetylated D-isomers of threo-β-phenylserine, threo-β-*p*-nitrophenylserine and phenylglycine were hydrolysed more easily than the corresponding N-dichloroacetylated L-isomers, suggesting the possible occurrence of D-acylase in this bacterial species. The present communication is concerned with evidence for the occurrence in Nature of D-acylase, which hydrolysed only the D-forms, but not the L-isomers of N-acylated amino-acids.

*KT*83 was grown in 1 litre of bouillon at 25° C. for two days, and the cells were then harvested by centrifugation and washed with distilled water. The yield of cells, in wet weight, was approximately 14 gm. The cells, after having been ground with alumina, were extracted with 40 ml. of distilled water. Crude extract thus obtained was dialysed against cold distilled water for 15 hr. To 40 ml. of the dialysed crude extract was added 8 ml. of a 1 per cent solution of protamine sulphate, and the precipitate resulting was removed by centrifugation. To the clear supernatant fluid was added 24 ml. of a 1 per cent solution of protamine sulphate. The white precipitate, which contained most of the activity of L-acylase, was separated by centrifuging, and dissolved in 1·5 *M* sodium chloride solution and dialysed first against 1·5 *M* sodium chloride solution for 30 hr., and secondly against distilled water for 20 hr. (partially purified L-acylase sample).

At the same time, the clear, straw-coloured supernatant, which contained most of the activity of D-acylase, was fractionated by addition of increasing amounts of saturated ammonium sulphate. The fraction which was precipitated between 50 and 60 per cent saturation of ammonium sulphate and which would be most active was dialysed against distilled water for 10 hr. until free of ammonium sulphate. The inside fluid was then centrifuged to remove inactive protein which was precipitated during the dialysis (partially purified D-acylase sample).

The enzymatic assay was performed according to Grassmann and Heyde's method. Protein was determined by the phenol method of Lowry *et al.* The acylase-activities of crude extract, partially purified L-acylase and partially purified D-acylase, are shown in Table 1.

Table 1

Enzyme sample	Specific activity		Total activity	
	Benzoyl-phenylalanine		Benzoyl-phenylalanine	
	D-	L-	D-	L-
Crude extract	2·3	11·5	1,035	5,175
Partially purified L-acylase	1·0	23·0	120	2,760
Partially purified D-acylase	32·0	< 0·03	520	< 0·5

Expressed as micromoles hydrolysed per hr. per mgm. protein. The digests consisted of 0·5 ml. enzyme solution, 0·5 ml. of water and 1 ml. of 0·05 *M* neutralized substrate (*p*H 8) at 37° C.

On the other hand, the resolution experiment, in which 6 ml. (15 mgm. of protein) of the partially purified D-acylase sample was made to act on 1·35 gm. of benzoyl-DL-phenylalanine at 37° C. for 20 hr., gave the following results: 0·33 gm. (80 per cent) of D-phenylalanine $[\alpha]_D^{15} = +35{\cdot}0°$ ($c = 2$, H_2O); 0·57 gm. (84 per cent) of benzoyl-L-phenylalanine $[\alpha]_D^{15} = +14{\cdot}9°$ ($c = 3$, *N*NaOH) m.p. 139–40°; 0·25 gm. (82 per cent) of benzoic acid m.p. 118–20°.

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Japan. Feb. 21.

[1] Kameda, Y., Toyoura, E., Yamazoe, H., Kimura, Y., and Yasuda, Y., *Nature*, **170**, 888 (1952).
[2] Kameda, Y., Toyoura, E., Kimura, Y., and Matsui, K., *Yakugaku Zasshi*, **78**, 202 (1958).

Colonization of *Anopheles funestus*

ATTEMPTS to colonize *A. funestus funestus* Giles, the second most important vector of malaria in Africa, commenced in 1954 and continued for three years. During 1955–56 the first successful colony of this mosquito was established from eggs laid by wild-caught females of *A. funestus*, given alternative feeds on human and guinea pig blood. The egg production of this colony was of short duration and small quantity, and the colony eventually died out after a few months.

In August 1957 another colony was established from wild-caught, gravid females maintained on guinea pig blood meals only. This colony, now in its eighth generation, is remarkable for its vigour and egg production. The eggs are laid on filter paper immersed in a dish filled with water; the larvæ are maintained in bowls filled with tap water with floating water weed *Elodea canadensis*. Larval food consists of pure dried yeast. Adults are kept in cages 1 cu.ft. capacity in total darkness; anæsthetized guinea pigs are used daily as a source of blood meals for female mosquitoes; males are fed on sugar solution freely available in the cage. The duration of the cycle from eggs to pupæ is about 21 days at the temperature 80–85° F. Two egg batches of this colony were sent by air to London where a subsidiary colony was successfully established. Studies on the taxonomy and bionomics of this colony are now in progress.

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Feb. 20.

The General Relationship between Test Factors and Person Factors; Application to Preference Matrices

THE application of factor analysis to correlations between persons had already become widespread among psychologists when it was made the subject of a special study by Burt and Stephenson shortly before the Second World War. They began in collaboration, but concluded by differing[1] in their

opinions concerning the relationship of person factors to test factors. The controversy spread for a time; interest has died down since, but no general agreement has been reached. Burt's proof that there is a functional relationship[2] unfortunately lacks generality, and weaknesses have been pointed out by Thomson[3] and others. A further generalization is required to settle the point.

Starting from X, a $p \times t$ matrix of scores of p persons on t tests, with characteristic element x_{ij}, a matrix of correlations between persons or between tests may be built up. When the former is required, every row of X is centred $\left(\sum_{i=1}^{t} x_{ij} \to 0\right)$ and normalized $\left(\sum_{i=1}^{t} x^2_{ij} \to 1\right)$. Hence X is converted into S_p, say, and the resulting matrix of correlations between persons equals $S_p.S_p'$. When the latter, the columns are centred and normalized $\left(\sum_{j=1}^{p} x_{ij} \to 0, \sum_{j=1}^{p} x^2_{ij} \to 1, X \to S_t, \right.$ say), and a $t \times t$ matrix of correlations is obtained equal to $S_t'.S_t$. Thereafter factor analysis proceeds.

In the former case X is being viewed as a scatter of t points in a p space, in the latter as a scatter of p points in a t space. The principal components found in the two cases are generally not identical. But as X is self-identical, it is axiomatic that some general functional relationship must exist between the two sets of components. Substituting SS' for M in the characteristic equation for any quadratic matrix,

$$Mx = \lambda x$$

(λ a non-zero latent root, x its associated vector) and pre-multiplying by S', we obtain:

$$S'SS'x = \lambda S'x$$

Hence λ is also a latent root of $S'S$ and its associated vector is $S'x$.

Thus when an efficient method of analysis is used, complications in the relationship between the components of $S_p.S_p'$ and $S_t'.S_t$ can only be due to differences in the way S_p and S_t are centred and normalized. They can always be avoided by strictly consistent treatment. We may use a $p \times p$ or a $t \times t$ matrix, whichever is more convenient, to obtain either the person factors or the test factors; but in the former case we must centre and normalize X by row, and in the latter by column, and pay no attention to the odd appearance of $S_p'.S_p$ or $S_t.S_t'$.

The problem of practical importance is to decide when one way of centring and normalizing is preferable to the other. The context of the particular experiment is decisive. But some generalization is possible. Centring X by row eliminates the variance between persons, and centring it by columns eliminates the variance between tests. We may prefer the way that eliminates least of the information. For example, when p people compare t objects by ranking them, all row totals are equal. We do not in fact find out whether A likes the whole set of objects any more than B, or less. Centring by row thus eliminates none of the information, whereas centring by column eliminates the net differences in people's preferences for particular objects. On the other hand, when the scores of p persons on t disparate tests are recorded, we generally have no way of telling whether the average score of the group is higher or lower on one test than another. Centring by column eliminates nothing, whereas centring by row eliminates differences between individuals in average performance on the whole battery of tests. Normalizing becomes necessary when different scales of measurement have been used, and nothing is known about their commensurability. When all the x_{ij} are commensurable, it has no advantages.

This leads us to an unusual way of looking at preference matrices. For the accompanying miniature example (Table 1), 8 people have rated 5 objects by the method of paired comparison. The number of times preference has been given to each object is recorded minus 2. The matrix, S, is thus centred by row. It is not normalized, as all the x_{ij} are commensurate. We do not wish to lose sight of the fact that preferences for T_4 vary more widely than for T_3, or that P_1 is more consistent in his preferences than P_8. The column totals are not an altogether satisfactory index of the prevalent ordering of the objects; their differences are reduced because P_7 and P_8 tend to follow it in reverse.

Table 1

Person	Preferences for object					First factor-loadings: for objects		for persons	
	T_1	T_2	T_3	T_4	T_5	T_1	−0·755	P_1	0·182
P_1	−1	−2	0	1	2	T_2	0·231	P_2	0·439
P_2	−2	1	0	2	−1	T_3	−0·184	P_3	0·232
P_3	−2	1	0	−1	2	T_4	0·569	P_4	0·475
P_4	−2	0	−1	2	1	T_5	0·138	P_5	0·249
P_5	−2	1	1	0	0			P_6	0·183
P_6	−2	0	2	0	0			P_7	−0·490
P_7	2	−1	1	−2	0			P_8	−0·399
P_8	1	−1	2	−2	0				
Total	−8	−1	5	0	4				

The principal component analysis is applied directly to the 5×5 matrix of sums of squares and products of S ($S'S$) by column. This gives in the first place a set of test loadings, l_1, normalized in Table 1, which shows the major operative order among the objects. Next $S'l_1$ gives us the person loadings, L_1, also normalized, which show how far and in what direction different people's responses reflect this order. There are of course only four latent roots; the first, $\lambda_1 = 39{\cdot}044$, contributes 53 per cent of their total. The matrix of deviations from expectation after its extraction could be obtained, if desired, from $\lambda_1^{1/2} L_1 l_1'$.

The similarities with Burt's procedure are easily recognized. But he centres his matrix by row and by column, and thus, one way or the other, eliminates too much of the variance and cannot obtain an exact fit.

My thanks are due to Prof. M. G. Kendall and Mr. J. G. Hayes. A further account of this work will appear in a Ph.D. thesis submitted to the University of London.

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Jan. 28.

[1] Burt, C., and Stephenson, W., *Psychometrika*, 4, 269 (1939).
[2] Burt, Sir Cyril, "The Factors of the Mind" (Univ. Lond. Press).
[3] Thomson, Sir Godfrey, "The Factorial Analysis of Human Ability" (Univ. Lond. Press).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 28

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal Evening on "Economic Usage of Broad-Band Transmission Systems". Talk by Mr. R. J. Halsey.

UNIVERSITY OF LONDON (in the Main Chemistry Theatre, Royal College of Science, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 5.30 p.m.—Dr. Heinz Zemanek (Technische Hochschule, Vienna): "Some Automata of the Eighteenth Century".*

ROYAL GEOGRAPHICAL SOCIETY (1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Dr. Audrey Richards, C.B.E.: "The Changing Pattern of Agriculture in East Africa To-day".

Monday, April 28—Friday, May 2

INSTITUTE OF METALS (at Church House, Great Smith Street, London, S.W.1), Golden Jubilee Meeting.

Tuesday, April 28

May Lecture.

Thursday, May 1

All-day Symposium on "Advances in Inspection Techniques as Aids to Process Control in Non-Ferrous Metals Production".

Tuesday, April 29

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, London, W.C.2), at 5 p.m.—Prof. R. M. Titmuss: "Health".* (Fourteenth of a series of lectures on "Law and Opinion in England in the Twentieth Century". Further lectures on May 6, 13 and 20.)

UNIVERSITY OF LONDON (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Paul Bernays (Zürich): "Recent Trends in the Foundations of Mathematics".* (First of four Sherman Memorial Lectures. Further lectures on May 1, 6 and 8.)

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting.

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Royal Institution, 21 Albemarle Street, London, W.1), at 7 p.m.—Miss Mamie Olliver: "Food Preservation" (Ladies Evening).

Wednesday, April 30

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 3 p.m.—Annual General Meeting.

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.30 p.m.—Révérend Père R. de Vaux (Jerusalem): "Troglodytes by Choice or by Necessity: the Caves of Murabb'at". (First of three Special University Lectures on "Recent Excavations in Palestine". Further lectures on May 2 and 5.)

SOCIETY OF CHEMICAL INDUSTRY (in the Lecture Theatre, Department of Chemistry, King's College, Newcastle-upon-Tyne), at 6 p.m.—Dr. R. Holroyd: "The Development of the Petroleum Chemical Industry in Britain" (Fifth Castner Memorial Lecture).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. W. F. Grimes: "The Temple of Mithras in Walbrook, London".

Thursday, May 1

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1, at 4.30 p.m.—Mr. T. F. Gaskell, Mr. M. N. Hill and Mr. J. C. Swallow: "Seismic Measurements made by H.M.S. *Challenger* in the Atlantic, Pacific and Indian Oceans and in the Mediterranean Sea, 1950–53"; Mr. M. H. P. Bott, Mr. A. A. Day and Mr. D. Masson-Smith: "The Geological Interpretation of Gravity and Magnetic Surveys in Devon and Cornwall".

INSTITUTE OF REFRIGERATION (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m.—Mr. G. Laing: "Marine Insulation".

UNIVERSITY OF LONDON (at the Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 5.30 p.m.—Prof. W. D. M. Paton: "The Pharmacology of Mucous Membrane".*

ROYAL PHOTOGRAPHIC SOCIETY (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Dr. Dubois de Montreynaud: "The Clinical Significance of New Types of Endoscope".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. B. Lythgow: "Some Recent Advances in the Chemistry of the Vitamins D" (Tilden Lecture).

Friday, May 2

LINNEAN SOCIETY OF LONDON, EXPERIMENTAL TAXONOMY GROUP (joint meeting with the SYSTEMATICS ASSOCIATION, at Burlington House, Piccadilly, London, W.1), at 11 a.m.—Symposium on "Apomixis".

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. C. W. Handscomb: "'Picking a Piece': Improving Attention and Motivation in an Industrial Situation".

Saturday, May 3

BRITISH INTERPLANETARY SOCIETY (in the Kent Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Annual General Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR LECTURER (with a good honours degree and teaching experience) IN APPLIED MATHEMATICS at the Nigerian College of Arts, Science and Technology—The Secretary, Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (April 30).

SENIOR LEVERHULME RESEARCH FELLOW for research in some aspects of radio-astronomy, using the radio telescope at the Jodrell Bank Experimental Station—The Registrar, The University, Manchester (April 30).

SHEPHERD RESEARCH FELLOW IN THE DEPARTMENT OF PATHOLOGY, for research on immunological problems of ocular disease—The Director, Department of Pathology, Institute of Ophthalmology, Judd Street, London, W.C.1 (May 1).

ASSISTANT, Grade B (man or woman), IN BIOLOGY, for G.C.E. Advanced Level Courses—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford, Essex (May 3).

SCIENTIFIC OFFICER (with a good honours degree in science) IN THE CYTOGENETICS SECTION, to engage in genetical and cytological research; and an ASSISTANT EXPERIMENTAL OFFICER (with at least a pass degree) IN THE POTATOES SECTION, to assist with genetical and breeding research—The Secretary, Plant Breeding Institute, Trumpington, Cambridge (May 3).

LIBRARIAN (with a scientific background, preferably with a pass degree or equivalent, and proficient in German), for a small but specialized library—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (May 9).

ASSISTANT IN THE DEPARTMENT OF ZOOLOGY—The Secretary, The University, Edinburgh (May 10).

ASSISTANT LECTURER (with special interests in theoretical physics, preferably in the field of solid state physics or of statistical mechanics) IN PHYSICS; and an ASSISTANT LECTURER (with special interests in experimental physics) IN PHYSICS—The Registrar, King's College, Strand, London, W.C.2 (May 10).

KEEPERS (with an honours degree in the appropriate subject, and preferably in possession of the Diploma of the Museums Association) IN THE DEPARTMENTS OF ETHNOLOGY AND GENERAL ARCHÆOLOGY, and BOTANY—The Registrar, The University, Manchester 13 (May 10).

CHIEF TECHNICIAN (with adequate experience in a chemistry laboratory and competent in glass blowing and other laboratory arts) IN THE DEPARTMENT OF CHEMISTRY, University College of Ghana—The Assistant Registrar (London), University College of Ghana, 29 Tavistock Square, London, W.C.1 (May 14).

UNIVERSITY ASSISTANT LECTURERS (2) (preferably specialized in analysis and applied mathematics) IN MATHEMATICS—The Secretary of the Appointments Committee of the Faculty of Mathematics, The Arts School, Bene't Street, Cambridge (May 14).

LEVERHULME FELLOW AND LECTURER (with a good knowledge of high energy nuclear physics) IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Liverpool (May 17).

LECTURER IN LIGHT ELECTRICAL ENGINEERING, and a SENIOR LECTURER IN ENGINEERING MATHEMATICS—The Secretary, The Queen's University, Belfast (May 20).

DIRECTOR—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading (May 27).

ASSISTANT LECTURER (with an honours degree in agriculture, agricultural botany or botany or equivalent qualifications) IN AGRICULTURE—The Registrar (Room 22, O.R.B.), The University, Reading (May 31).

CHAIR OF PURE MATHEMATICS, and CHAIR OF APPLIED MATHEMATICS in the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 31).

READER (preferably with special qualifications in engineering thermodynamics) IN MECHANICAL ENGINEERING, and a LECTURER (with special interests in inorganic chemistry) IN CHEMISTRY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, June 10).

BRITISH OXYGEN POSTGRADUATE RESEARCH FELLOWS (3), to pursue research in one of the following fields: (*a*) the chemical or physical properties of oxygen, nitrogen or the rare gases, (*b*) the applications of low temperatures, (*c*) the chemical reactions of acetylene, (*d*) the influence of oxygen, nitrogen, or argon in metallurgy, or (*e*) the electrical or metallurgical principles of welding—The Secretary, British Oxygen Fellowships Committee, Deer Park Road, London S.W.19 (June 11).

CHAIR OF ANATOMY in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, June 16).

CHAIR OF STATISTICS in Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 30).

RESEARCH STUDENTS (with the degree of Bachelor or Master of a British university other than Manchester) IN SCIENCE—The Registrar, The University, Manchester (July 1).

SENIOR LECTURER IN THE DEPARTMENT OF PHYSICS, Victoria University of Wellington, New Zealand—The Secretary, Association

of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 1).

Biochemist (experienced in techniques for steroid estimation), for research appointment with clinical endocrinology—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

Biologist (with a university degree in science, including botany and zoology, a diploma in education and/or teaching experience) in the Department of Agriculture, Uganda, to teach scientific subjects in an agricultural course of the standard of the Diploma Course of an Agricultural College in Great Britain and to share in the normal duties associated with a residential teaching establishment—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/9/030.

Research Assistant, for work on glyco- and muco-proteins—The Steward and Finance Officer, Department of Pathology, Royal Infirmary, Cardiff.

Senior Lecturer (qualified to direct research and to teach to honours degree or diploma in technology levels, and preferably with industrial experience in a responsible position) in Textile Physics—The Principal, Institute of Technology, Bradford 7.

Senior Technician or Technician (preferably with experience of histological or museum techniques) in the Zoology Department—The Secretary, Royal Holloway College, Englefield Green, Surrey.

Soil Scientist (Analyst) (with a good honours degree in chemistry or equivalent, and one or two years suitable postgraduate training or experience) in the Department of Agriculture, Western Region of Nigeria, to carry out soil analyses and nutritional studies on cocoa and annual crops as a member of a team—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/410/015.

Taxonomist (preferably single woman over 25, with a lively interest in, and good experience of, systematic botany) in the Uganda Government Agricultural Department, for duties which include the maintenance and enlargement of existing herbarium, arranging identification of specimens, starting a pathological collection and, if possible, minor taxonomic research—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3A/44598/NF.

Technician (suitable B.Sc. graduate might be considered), for poliomyelitis research under Prof. Wilson Smith, F.R.S.—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

General Register Office. Studies on Medical and Population Subjects, No. 12: The Survey of Sickness, 1943–1952. By Dr. W. P. D. Logan and Eileen M. Brooke. Pp. v+80. (London: H.M. Stationery Office, 1957.) 4*s*. net. [42

University of Cambridge. School of Agriculture Memoirs, No. 29: A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period October 1st, 1956—September 30th, 1957. Review Series No. 12: Entomology and Nematology in the School of Agriculture, 1899–1956. Pp. 31. (Cambridge: School of Agriculture, the University, 1957.) 3*s*. [42

Royal Institute of Chemistry. Lectures, Monographs and Reports, 1957. No. 4: Coal and Coal Chemicals in the National Economy. By Dr. J. Bronowski. (Tenth Dalton Lecture.) Pp. ii+24. (London: Royal Institute of Chemistry, 1957.) 4*s*. net. [42

The Engineer Buyers' Guide, 1958. Pp. 888. (London: *The Engineer*, 1958.) 7*s*. 6*d*. [42

The Dawn of Civilization: a Preliminary Outline of the Evidence of Divine Interest in the Welfare of the Human Race and Its Cultural Development. By John Swarbrick. Pp. 29+10 plates. (Cheam: The Wykeham Press, 1957.) 6*s*. [42

Professional Training for Engineering Graduates. New and entirely revised edition. Pp. 31. (Rugby: British Thomson-Houston Company, Ltd., 1958.) [42

Forestry Commission. Bulletin No. 17: Cultivation of the Cricket Bat Willow. Pp. vi+34+33 plates. (London: H.M. Stationery Office, 1958.) 5*s*. net. [42

Vacuum: a Review of Developments in Vacuum Research and Engineering. Vol. 5, October, 1955. (Annual Issue published November, 1957.) Pp. iv+345+v–xi. (Crawley: Edwards High Vacuum, Ltd., 1957.) 50*s*.; 7 dollars. [42

Aerodynamics: a Series of papers revised and reprinted from *Research*, Vol. 10, 1957. Pp. iii+47. (London: Butterworths Scientific Publications, 1957.) 7*s*. 6*d*. [42

British Medical Bulletin, Vol. 14, No. 1 (January, 1958): Anaesthesia. Pp. 72. (London: The British Council, 1958.) 20*s*. [42

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 981, Vol. 250 (23 January 1958): The Lubrication of Rollers. By A. W. Crook. Pp. 387–409. (London: Royal Society, 1958.) 7*s*. [42

Tobacco Manufacturers' Standing Committee. Research Papers, No. 1: Statistics of Smoking. Edited by G. F. Todd. Pp. 64. (London: Campbell-Johnson, Ltd., 1957. Issued on behalf of the Tobacco Manufacturers Standing Committee.) [42

An Attempt at a Statement Concerning a Vital Unit as Shown by the Reed in the Delta of the Danube. By Marietta Pallis. Pp. 24. (Glasgow: Robert Maclehose and Co., Ltd., 1958.) [42

Society of Chemical Industry. S.C.I. Monograph No. 2: The Comparison of High- and Low-Volume Spraying Techniques on Fruit and Ground Crops. (Comprising papers (with discussion) read at a Symposium organized by the Pesticides Group, held at the Wellcome Building, London, N.W.1, 11–12, December, 1956.) Pp. iv+117. (London: Society of Chemical Industry, 1958.) 18*s*. [42

National Institute of Agricultural Botany. Farmers Leaflets. No. 3: Varieties of Potatoes. Pp. 6. No. 8: Varieties of Winter Wheats. Pp. 4. No. 9: Spring Wheats. Pp. 2. No. 10: Varieties of Barleys. Pp. 4. No. 13: Varieties of Oats. Pp. 4. (Cambridge: National Institute of Agricultural Botany, 1958.) [42

Annals of the International Geophysical Year. Vol. 3, Part 1: Pp. xix+168. Vol. 3, Parts 2, 3 and 4: Pp. 169–381. Vol. 4, Parts 1, 2 and 3: Pp. 202. Vol. 4, Parts 4–7: Pp. 203–393. Vol. 5, Parts 1–3: Pp. 244. Subscription per volume: 120*s*.; 17 dollars. (London and New York: Pergamon Press, 1957.) [102

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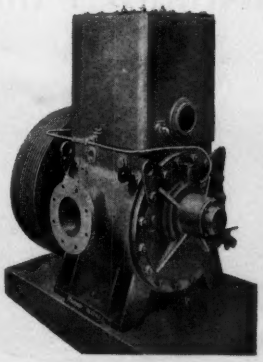

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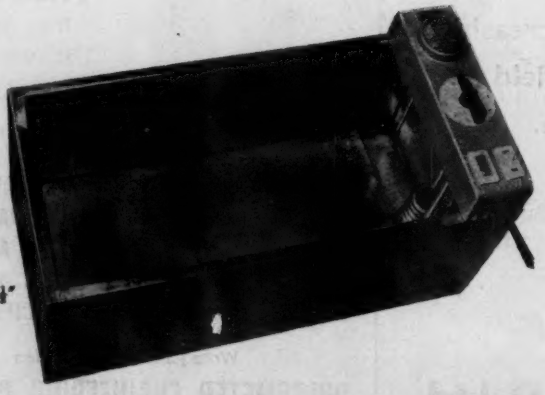

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